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Two performance tests of teaching proficiency in the field of trade and industrial education were developed during this project, one in the field of auto mechanics (carburetion) and one in the field of electronics (power supplies). An assessment was made of each test's ability to distinguish between experienced teachers and the non-teacher with respect to their ability to achieve pre-specified instructional objectives. All subjects, teachers and non-teachers, were given sets of operationally defined objectives. They attempted to achieve goals during an instructional period of approximately 10 hours. Pre- and post-tests based explicitly on the objectives were given to each subject's pupils, and average class achievement was used as the index of the teacher's proficiency. Twenty-eight auto mechanics teachers and 28 non-teachers instructed over 1,200 pupils while 16 electronics and 16 non-teachers instructed over 700 pupils. Comparisons of pupil performance data revealed no systematic differences between the performance of the teacher and non-teacher group of either auto mechanics or electronics. These results were attributable to problems associated with the training of teachers as well as the reinforcement structures operating when they commenced training. (EM)

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PERFORMANCE TESTS OF INSTRUCTOR COMPETENCE FOR TRADE AND TECHNICAL EDUCATION

June 1968

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PERFORMANCE TESTS OF INSTRUCTOR COMPETENCE FOR TRADE AND TECHNICAL EDUCATION

W. James Popham

University of California, Los Angeles

Los Angeles, California

June 1968

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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INTRODUCTION

One of the most elusive targets in the history of educational research is a valid index of teacher effectiveness. Since the turn of the century literally hundreds of investigations have probed the question of teacher competence assessment and most of them have produced little, if any, significant progress.

In the last few years, however, evolving conceptions of the nature of instruction seem to offer promise to teacher effectiveness researchers. In most of the early investigations in which measures of teacher effectiveness were sought, there was an almost exclusive focus on the instructional means employed by teachers. Researcher after researcher attempted to identify "good teaching procedures" for, should such procedures be discovered, they would obviously have implications both for pre- and in-service teacher education, as well as for the evaluation of teachers on the job. Only recently have many educators come forward who are more inclined to accept the proposition that there are literally a variety of instructional means which can be used to bring about a single instructional end. This more recent thinking suggests that the focus in the evaluation of instruction should be on the results achieved by instructors, irrespective of the means they employ.

When Morsh and Wilder in their definitive review[1] of teacher effectiveness research during the first fifty years of this century indicated that no single teaching act had been discovered which was invariably associated with learner achievement, teacher competence researchers should have been more attentive. We should have first focused our efforts on identifying teachers who could produce superior growth in learners, leaving aside for the moment the question of how such improvements were brought about. If one can identify satisfactory measures of pupil attainment, then the next step is to identify the complicated procedures by which such achievements are attained. To repeat, the first task is to isolate satisfactory measures of quality instruction, the second is to use those measures to discover the means which contribute to teaching prowess. It is important to emphasize the complexity of this task, for the undoubted reason that reviewers such as Morsh and Wilder found few references to "good teaching procedures" is that effective instruction surely represents a series of subtle interactions among a given teacher, his particular students, the instructional goals he is attempting to achieve, the instructional environment, etc.

Of course, there have been researchers who have employed the criterion of learner growth as an index of a teacher's proficiency. Such efforts would seem to represent proper attention to instructional ends rather than means. Unfortunately, most of these investigations relied upon the use of broad, standardized achievement tests which, while comprehensive, rarely took into consideration the idiosyncratic nature of an instructor's particular inclinations regarding what ought to be taught. Such gross measures of learner achievement invariably were reported as being too insensitive. Further, the standardized measures employed were invariably based on norm-referenced rather than criterion-referenced approaches to test construction and, as a consequence, were often inappropriate to measure group progress toward instructional goals.

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[1] Joseph E. Morsh and Eleanor Wilder, "Identifying the Effective Instructor: A Review of the Quantitative Studies, 1900-1952," Research Bulletin AFPTRC-TR-54-44, Lackland Air Force Base, Texas, 1954.

Because of the methodological difficulties encountered to date by teacher effectiveness researchers, a heretofore untried procedure for assessing teaching competence was conceived at the University of California, Los Angeles during the year 1964. The heart of this procedure involved the use of so-called "performance tests of teaching proficiency." Two proposals were submitted to the U.S. Office of Education and support was secured from that agency for two related investigations, one of which was designed to develop and test a validity hypothesis regarding a performance test in the field of social science. Results of this investigation have been previously reported.[2]

The second study was to be conducted in the fields of vocational education and called for the development of two performance tests in that general area, more specifically, in the areas of (a) electronics and (b) auto mechanics. The present report describes results of the latter investigation.

Rationale. In brief, the general approach used in the performance tests of teaching proficiency calls for a set of instructional objectives to be developed in extremely explicit terms to cover an instructional period of approximately nine to ten hours. Coupled with such objectives are examinations based explicitly on the objectives. In addition, a collection of possible instructional activities and references are provided in a form comparable to the "resource units" found in so many curriculum libraries. The procedure for using such performance tests requires that an instructor be given the objectives and resource materials well in advance of instruction, is told to devise a sequence of instruction suitable for accomplishing the objectives, and then allowed to teach to the objectives using whatever instructional procedures he wishes. In other words, only the ends are specified, the means are left free to the instructor. A participant in our investigation would be obliged, therefore, to attempt to accomplish the prespecified objectives, but would have complete freedom to choose instructional procedures which, to him, seemed likely to achieve those goals.

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[2] W. James Popham, Development of a Performance Test of Teaching Proficiency, Department of Health, Education and Welfare, Project No. 5-0566-2-12-1, Contract No. OE-6-10-254, Final Report, 1967.

It is difficult, of course, to validate the merits of such an approach to the assessment of teaching competence. One does not have readily available the already established criterion measures which can be used to calculate concurrent validity coefficients. A construct approach to validation, therefore, appeared to be more appropriate. It seemed, considering the nature of the performance tests, that these measures ought to be able at least to distinguish between experienced teachers and those who have never previously taught. In other words, if one were to take a group of experienced teachers and ask them to teach to the objectives, in contrast to asking a group of "people off the street" to teach to the same objectives, the experienced teachers ought to out-perform their inexperienced counterparts. In order to test this validation hypothesis, it was proposed that performance tests be developed in the two fields previously mentioned and that the ability of the tests to discriminate between experienced teachers and nonteachers be determined. The project was initiated in May, 1965, and was concluded in June, 1968. Results of developmental work and field tests will be described in the following pages.

Related Results of the Social Science Performance Test Investigation. Because of its relevance to the present investigation, a somewhat extensive summary of the investigation dealing with the social science performance test should be presented. Accordingly, an abstract of that investigation is presented in full.

> A project was undertaken to develop and, hopefully, validate a heretofore untried method of assessing teacher competence, namely through the use of a performance test. The performance test was designed to function in the following way. Teachers were presented with a list of specific, operationally defined objectives for a particular topic and directed to teach the objectives. Following the instructional period, students were tested on the behaviors stated in the objectives. Teacher competence was judged in relationship to the way their students performed on the criterion test. An attempt to validate this method of measuring teacher effectiveness involved contrasting the results produced by experienced teachers and nonteachers on a performance test dealing with research methods in the social sciences.
>
> Two separate contrasts were conducted, the first involving six professionally trained, experienced student teachers versus six housewives for a six hour teaching period. The second involved thirteen regularly credentialed teachers and thirteen college students for a four hour teaching period. In neither contrast did the teachers perform significantly better than the nonteachers.
>
> The results were interpreted as indicating that the experienced teachers were not more experienced than the nonteachers in promoting learner achievement of previously established instructional objectives. An alternative approach

to validating the performance test strategy was discussed along with possible procedural modifications in the approach.

Because of the failure to support the validation hypothesis in connection with the social science performance test investigation, we were particularly anxious to learn whether tryouts of the two performance tests to be developed in the present investigation would confirm the validation prediction.

TEST DEVELOPMENT

Early months of the project were devoted to selection of tentative topics for the performance tests. The fields of electronics and auto mechanics had been selected because of the frequency with which such courses are taught in the public schools. But beyond the general topics, there was the specific question of what units would be appropriate for the performance tests. Ideally, it was judged that topics should be (1) sufficiently important so that teachers would be willing to include them in their curricula, and (2) sufficiently autonomous so that the units could be inserted rather freely at various points during the academic year. With these criteria in mind, the topic selected for the electronics unit was the "General Principles of Electronics Troubleshooting," and the topic selected for auto mechanics was "Carburetion."

Developmental work on the two units occurred in the following pattern: First, topics meeting the above criteria which might be covered in two or three weeks were selected. These were then submitted to several subject matter specialists who served as consultants during the project. From these tentative topics, the two mentioned above were selected and instructional objectives were prepared which were also screened by consultants. A preliminary set of these objectives was agreed on, and test items based directly on the objectives were developed. In addition, possible learning activities and reference materials were assembled. In some instances, these learning activities were designed to be particularly pertinent to the given objectives. In other cases, the activities were planned to be "flashy" but not germane to the objectives. It was thought that less experienced instructors might be attracted to the "flashy," irrelevant activities, but that the sophisticated teacher would tend to use the pertinent activities. These materials were revised several times prior to an initial trial. Of course, it was possible that the teacher might choose to develop his own activities and not use any of the materials provided in the unit.

The early forms of the post-tests were given to several teachers for administration to classes of students currently taking electronics or auto mechanics courses. Resulting data underwent item analysis procedures which resulted in improvement of many test items.

When ready for the first field trial, both the carburetion and electronics units consisted solely of objectives measurable by paper and pencil tests. The instructional time allotted to each was ten hours.

The carburetion materials (with 49 objectives) consisted of 22 pages while the electronics unit (with 23 objectives) consisted of 41 pages. Both units were considered incomplete, for it was planned during the second year to add objectives demanding performance on actual carburetors and electronics circuit boards.

For each unit a pre- and post-test were prepared. The post-test for electronics consisted of 52 multiple-choice items and the post-test for carburetion consisted of 97 multiple-choice items. Both of these tests were drawn specifically from the objectives. Items for the pre-tests were randomly selected from the post-test items in order to provide measures which could be completed in approximately 20 minutes. The pre-test for electronics contained 17 items while the carburetion pre-test had 20 items.

Initial Tryout. Both performance tests were given their first test during January and February, 1966. The electronics test was tried out in eight electronics classes at Los Angeles Trade Technical College.[3] The carburetion performance test was tried out in two classes, one at the junior college level at Los Angeles Trade Technical College, and one at Fullerton Union High School.[4] Thirty-six students took part in the carburetion tryout and 108 students in the electronics tryout.

Each instructor was given a copy of the unit objectives and the resource materials approximately one week prior to the time he was to teach the unit. Each was instructed to attempt to accomplish the objectives stated in the unit, but to use any instructional techniques he wished. For purposes of this trial, participating instructors were also asked to make suggestions regarding ways in which the materials could be improved.

Arrangements were made with each teacher so that a member of the research staff administered (1) a twenty minute pre-test during the first day of the ten hours devoted to the unit and (2) a fifty minute post-test at its conclusion. In addition, a questionnaire was administered to the students at the close of the unit. A questionnaire was also given to the teacher at that time soliciting his suggestions regarding the unit. Finally, in two of the electronics classes and one carburetion class the Wonderlic Personnel Test, a twelve minute test of "problem-solving ability" was administered to the students at the time of the pre-test. In all, 25 different variables were represented by the two questionnaires and the Wonderlic. The trials were completed between the dates of January 17 and February 10, 1966.

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[3] Appreciation is expressed to the administration and staff of Los Angeles Trade Technical College for their participation in this investigation.

[4] Appreciation is also expressed to the administration and staff of Fullerton Union High School for their participation in this investigation.

Analysis. Two different types of analyses were conducted on the preliminary data. The first was to compute item analyses and coefficients of internal consistency (Kuder-Richardson Formula 20) on the pre- and post-tests. The second was to compute intercorrelations among the several measures. Key interest in the latter analysis focused on the possibility of detecting variables which could be used, in part, to control for differences among the pupils due to such factors as "set" toward the unit's material, intelligence, etc. Further, of course, the responses of the instructors were carefully considered. The overall purpose of the initial analysis was essentially heuristic. We were attempting to find possible variables to be considered in subsequent trials of the materials.

It was fully expected that a great number of deficiencies would exist in the first experimental versions of both of the performance tests. Procedural defects regarding such details as test administration, relations with instructors, etc. were also anticipated.

Results. The performance of students in this first extensive field test is summarized in Table 1. Item analysis results revealed a considerable number of items, particularly in the electronics tests, which were in need of revision. The KR_{20} coefficients were markedly higher for the carburetion tests than for the electronics tests.

Table 1

Electronics and Carburetion Pre- and Post-Tests Results

	Electronics					Carburetion				
	n	items	$\overline{X}$	s	$KR_{20}r$	n	items	$\overline{X}$	s	$KR_{20}r$
Pre	108	17	9.68	2.71	.56	36	20	10.41	3.48	.71
Post	98	52	23.68	9.57	.44	33	97	51.64	17.86	.78

Of the 25 variables constituting the pupil and teacher questionnaires and the Wonderlic test, interest centered on those which might be of value in adjusting for initial differences among pupils and/or teachers. In the case of both carburetion and electronics, the variables which were most strongly related to post-test performance were: (a) pupils' overall grade point average, and (b) pupils' estimate of the pre-test's difficulty, i.e., the students who thought it easier tending to score higher on the post-test. Negligible correlations existed between post-test scores and (a) pre-test performance or (b) Wonderlic performance.

The chief suggestions from participating instructors concerned the addition and deletion of certain objectives for the units. A number of criticisms were made of the technical terminology employed in the objectives and reference materials. Many instructors thought that the topics could not be adequately treated in ten instructional hours. Many minor deficiencies in the quality of the reference materials were also noted.

In the case of the carburetion test, several additional small-scale trials were conducted during the spring of 1966, resulting in a number of revisions of the instructional materials, but in the overall confirmation of the choice of carburetion as a suitable topic for the instructional unit. Revisions in three experimental versions resulted in a 27 page set of resource materials to be given to participants in the study. In these materials were included 29 specific instructional objectives (as opposed to the previous 49 objectives), a 99 item post-test and a 20 item pre-test based on the objectives. The student questionnaire was refined so that it consisted of a 17 item instrument. The instructor questionnaire of 16 items was also modified. All of the materials were surveyed numerous times by vocational education consultants, usually junior college and high school auto mechanics instructors.

The disappointing results with the unit on electronics troubleshooting led to a serious reappraisal of the value of that particular topic. After extensive consultation, particularly with a number of practicing electronics instructors, a complete shift of topic was undertaken and a new unit was developed on the topic of "Basic Power Supplies." After three revisions, an experimental version was completed in January, 1967, consisting of 30 pages and 23 specific instructional objectives. A 73 item post-test, a 20 item pre-test, and student and teacher questionnaires comparable to those used with the carburetion unit were prepared. These materials were examined by many electronics teachers and the response of consultants to the newly selected topic was most encouraging.

The tests for the new electronics performance measure were administered to almost 100 subjects in an early field trial. Thirty-three of these were advanced junior college students whose performance could be considered that of sophisticated learners, that is, those who should know the material treated in the test. An encouraging Kuder-Richardson (20) internal consistency coefficient of .91 was yielded on the basis of this tryout. The test took approximately 90 minutes to complete, however, and had to be shortened. This was done according to results of item analyses on the total tryout results.

After several revisions, particularly in the tests, the final set of electronics materials consisted of a 30 page unit which included 23 specific objectives, a 20 item pre-test plus a 46 item post-test based on those objectives, a 17 item student questionnaire, and a 16 item teacher questionnaire comparable to those in the carburetion unit. These revised materials were field tested on several small classes of students and results indicated suitability for use in the formal test of the validation hypothesis. Copies of all of these materials are included in the Appendices.

METHOD

The general approach to be employed in testing the validation hypothesis called for the identification of experienced teachers in the fields of electronics and auto mechanics and then comparing the achievement of their students in a performance test situation with the achievement of students taught by nonteachers. Accordingly, after developing the performance test materials, our next task was to locate a suitable number of teachers and nonteachers. This endeavor proved to be the most trying operation of the entire research project. At first we solicited the cooperation of large districts in which there would be a number of vocational education teachers in the desired fields. We also hoped to conduct our study in relatively large metropolitan areas where we might be able to locate numerous nonteachers who would have sufficient technical backgrounds to teach the units, but no prior teaching experience. In the case of the auto mechanics performance test, we anticipated using garage mechanics from service stations, auto agency service departments, etc. For the electronics performance test we hoped to recruit individuals such as television repairmen and workers in electronics industries.

The response from most large school districts in the state of California was both consistent and discouraging. For a variety of reasons, large districts were unwilling to participate. For example, the most convenient large district (to our research staff) had an unwritten board policy against evaluating personnel following employment. This policy precluded the conduct of such studies, even if teachers volunteered to participate. Other districts indicated an unwillingness to have a non-credentialed teacher in the classroom, although legal requirements could be satisfied by the regular teacher's remaining in the classroom. Of all the large districts contacted throughout the state, only the San Diego City Schools[5] agreed to participate in the project. In addition, a number of school districts in Orange County agreed to participate in the project.

The unanticipated difficulties in securing participants for the investigation actually delayed completion of the project by a full year. A request for a temporal extension of the contract from the U.S. Office of Education was graciously approved.

In addition to the location of districts which would participate, there was also the problem of locating teacher volunteers as well as nonteachers who would agree to teach in the schools. Because of their extra effort involved in this project, an honorarium of $50 was given to each participating teacher. Since the nonteachers would usually be obliged to take time away from their regular jobs, a $75 honorarium was given to each participating nonteacher.

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[5] As previously indicated in the acknowledgements, we are inordinately appreciative of the willingness of the San Diego City Schools to become participants in this project.

As an added inducement to participate in the project, teacher volunteers were promised certain equipment which could be used by their students (as well as the students taught by the nonteacher) during the unit. At the conclusion of the unit this equipment was to be left with the teacher for his use with other classes. In the auto mechanics class one carburetor was provided for approximately every four to six pupils. In the electronics classes a power supply kit consisting of one transformer, one capacitor, and four transistor diodes was provided for approximately every two or three pupils.

The difficulty of locating nonteachers was considerable. Research assistants assigned to the project had incredible difficulty in indentifying a suitable number of nonteachers who were both willing to participate in the project and could arrange their schedules in order to teach in the schools. We finally relied on a major amount of newspaper advertising in order to attract the attention of nonteachers. We tried to slant our call for participants so it would be particularly appealing to the nonteachers. We referred to them as "industrial specialists" and attempted to describe the value of the contribution they would make to the project. After untold hours of telephone conversations, letters, etc., a sufficient number of teachers and nonteachers were located so that we had 28 pairs (teacher and nonteacher) for the auto mechanics field test and 16 pairs for the electronics field test.

Because of the necessity of controlling the potential influence of "school effects" in the data analysis, we located a nonteacher "match" for every teacher who agreed to participate in the project. In all instances teachers were selected who had at least two sections of a class in which the unit could be taught for approximately nine hours. For electronics, the following kinds of classes were usually involved: first and second year electronics and introductory electricity. For auto mechanics the following kinds of classes were generally involved: first and second year auto mechanics and power mechanics.

In almost all instances one of the classes was randomly designated as that which would be taught by the teacher. We were anxious to avoid the possibility that teachers would select one of their "best" classes and, consciously or unconsciously, give the less able group to the nonteacher. In some instances, of course, the schedule of a particular tradesman dictated the selection of a certain class hour for him. In this instance, if more than one class was available to the regular teacher, the class to be taught by the teacher (for the project) was selected at random. A collection of all invitation letters and signup forms used with the participants is found in the Appendices.

In general, the procedure involved giving the teacher and nonteacher sets of the instructional materials, that is, objectives and resource materials, approximately two weeks prior to the time when instruction was to commence. Then a member of the project research staff (or, in some cases, the teacher and nonteacher themselves) administered the pre-test to all students at the beginning of ten hours reserved for the project. The pre-test took approximately 15 to 20 minutes to complete. The results of the pre-tests were immediately put into an envelope and returned by mail to the project staff. The regular teacher and nonteacher then, in their separate classes, taught for approximately nine hours. They attempted to achieve the objectives specified in the unit but, as indicated before, were free to use any methods they wished. For legal purposes, while the nonteacher instructed, the regular teacher remained at the rear of the classroom but was instructed not to interfere with the nonteacher's efforts. At the conclusion of the nine hours of instruction, the regular teacher or a member of the project staff opened a sealed envelope and administered the post-test to all students. These materials, along with a brief student questionnaire and instructor questionnaire, which were also filled out at the conclusion of the unit, were returned to the project staff.

ANALYSIS

Because of the interaction among pupils in given classes, it was considered appropriate to treat the data in terms of classroom units rather than individual pupils. Accordingly, the first step in the analysis called for the calculation of classroom means for each of the variables involved in the investigation. These means, then, constituted the data for subsequent analyses. The principal analysis concerned the test of the prediction that teachers would significantly out-perform nonteachers. Two analyses were conducted to test this hypothesis. The first was a correlated *t* test using the gross post-test score as the criterion. The second was an analysis of covariance in which pre-test scores and students' grade point averages served as covariates. Separate analyses, of course, were conducted for electronics and carburetion data.

Results of pupil affective data on the questionnaires were compared by analyses of variance. As indicated previously, all of these analyses involved classroom means rather than data for individual pupils.

One case involving data for individual pupils, however, involved the calculation of Kuder-Richardson 20 internal consistency coefficients. These coefficients were based on the computations for the entire pool group of 710 students in the electronics classes and 1,248 students in the carburetion classes.

RESULTS

For simplicity of exposition, results of the electronics and auto mechanics analyses will be described separately.

Auto Mechanics. The initial analysis conducted was the determination of means and standard deviations for each of the classes taught by the 28 auto mechanics teachers and the 28 nonteachers. In a sense, of course, these represented *pairs* of instructors because a given teacher and nonteacher were instructing in a particular school. Results of these computations for pre- and post-test performance of the auto mechanics classes are presented in Table 2.

Table 2. Class Pre- and Post-Test Means and Standard Deviations of 28 Auto Mechanics Teacher and Nonteacher Pairs

	Pre-Test			Post-Test		
	n	$\bar{X}$	s	n	$\bar{X}$	s
Teacher	19	11.2	2.5	18	55.1	8.2
Nonteacher	22	11.1	2.1	20	51.5	9.7
Teacher	23	9.3	2.6	22	54.8	11.8
Nonteacher	22	10.0	2.3	19	47.6	10.8
Teacher	18	10.8	2.4	23	46.6	11.8
Nonteacher	22	11.5	1.7	19	46.3	9.4
Teacher	9	10.1	2.5	11	58.0	11.2
Nonteacher	19	10.4	2.3	23	65.7	10.5
Teacher	23	10.2	2.2	24	52.5	13.4
Nonteacher	22	10.8	2.3	24	50.4	10.7
Teacher	25	9.4	2.2	25	41.5	10.1
Nonteacher	24	9.4	2.6	20	45.7	12.2
Teacher	18	12.8	2.0	18	59.4	10.9
Nonteacher	19	9.4	2.7	19	40.8	8.8
Teacher	13	11.1	2.7	19	53.3	13.2
Nonteacher	20	10.8	2.4	20	56.6	8.8
Teacher	20	9.1	3.0	22	40.0	11.7
Nonteacher	21	7.8	3.6	21	47.3	11.9
Teacher	26	9.5	2.6	24	45.5	11.0
Nonteacher	26	9.7	2.7	22	43.3	9.1
Teacher	24	9.5	2.3	22	44.7	7.9
Nonteacher	22	9.5	2.5	19	37.8	11.0
Teacher	24	9.0	2.9	23	42.7	9.2
Nonteacher	26	11.6	2.3	22	48.3	7.0
Teacher	26	8.7	2.8	26	44.2	14.3
Nonteacher	19	8.6	2.7	16	42.3	10.8
Teacher	28	9.6	2.7	30	45.1	13.9
Nonteacher	27	10.5	3.0	28	50.8	14.3
Teacher	20	10.6	2.0	24	49.5	6.9
Nonteacher	20	9.6	2.2	21	50.1	9.9

Table 2. (Continued)

	Pre-Test			Post-Test		
	n	$\bar{X}$	s	n	$\bar{X}$	s
Teacher	15	6.3	2.9	17	37.0	7.7
Nonteacher	22	7.9	3.0	21	31.5	8.9
Teacher	18	10.0	2.5	18	48.3	12.4
Nonteacher	16	5.2	1.4	19	44.6	13.1
Teacher	17	6.5	1.7	18	39.1	10.9
Nonteacher	24	6.1	1.3	24	38.1	11.6
Teacher	28	9.9	2.7	28	46.6	8.6
Nonteacher	21	9.6	2.5	21	48.1	14.4
Teacher	17	9.5	2.2	19	50.1	12.7
Nonteacher	23	10.0	2.7	21	47.9	10.6
Teacher	21	10.1	2.5	21	52.6	10.5
Nonteacher	23	11.0	2.6	23	53.4	10.3
Teacher	9	9.6	3.2	6	47.5	8.0
Nonteacher	11	9.4	1.5	6	50.5	9.9
Teacher	15	11.2	2.4	17	60.8	9.1
Nonteacher	25	10.7	2.5	26	48.7	8.3
Teacher	18	8.6	2.4	20	42.2	9.9
Nonteacher	6	9.6	3.4	6	34.5	13.5
Teacher	17	9.9	2.3	18	52.0	9.9
Nonteacher	16	10.2	2.0	18	51.2	8.8
Teacher	25	9.8	3.1	22	50.2	12.4
Nonteacher	13	9.9	2.5	14	43.5	8.6
Teacher	19	9.1	1.9	19	33.4	11.1
Nonteacher	18	10.1	2.8	20	41.3	17.5
Teacher	26	10.3	3.1	28	48.0	10.7
Nonteacher	30	10.9	2.4	28	44.1	10.4

Several preliminary analyses were then conducted with the auto mechanics data. The first of these was a calculation of internal consistency (Kuder-Richardson 20) coefficients for the pre- and post-tests. These were calculated on the basis of the entire sample of pupils, considered irrespective of (a) class and (b) whether or not they were taught by a teacher or a nonteacher. The Kuder-Richardson 20 coefficient for the pre-test was .50 and for the post-test was .88.

Another preliminary analysis involved the computation of intercorrelation matrices in which post-test performance was correlated with pre-test performance, as well as a number of variables reported by pupils in the student questionnaire. It was hoped that by inspecting the relationships among post-test performance and these variables that two or three measures could be identified which were (a) highly correlated with the post-test but (b) only moderately correlated with each other. Such variables would, of course, be suitable for the anticipated analysis of covariance which was to be performed. We were, in other words, looking for useful control variables for that analysis. Intercorrelation matrices were computed both on the basis of all pupil data, analyzed student by student rather than by class, and also based on class by class results. In the case of the auto mechanics data, the most useful covariates appeared to be (a) pre-test scores and (b) pupils' expressed interest in the field of auto mechanics. The correlations based on class means yielded an r of .59 between pre- and post-test scores, an r of .59 between post-test and expressed interest, and an r of .28 between pre-test and expressed interest.

The next analysis involved a comparison of the pre-test performance of the teacher and nonteacher classes. Because of the probable similarity of the performance of pairs of classes within a given school, a product-moment correlation coefficient was first calculated to determine the relationship between the teacher and nonteacher pre-test means on the basis of school. The correlation in this instance was .50. Because of this relationship, a correlated t test model was employed to test for significance or difference between the pre-test means of the teacher and nonteacher classes. In Table 3 the means, standard deviations, and correlated t test result for pre-test performance of the 28 auto mechanics teacher and 28 nonteacher classes are presented.

Table 3. Means, Standard Deviations, and Correlated t Test Result for Pre-Test Performance of Auto Mechanics Teacher and Nonteacher Classes

	n	$\bar{X}$	s	t
Teacher	28	9.8	1.3	.10
Nonteacher	28	9.7	1.4	

As can be seen from an inspection of Table 3, the pre-test means of the two groups were almost identical. The correlated t test yielded a nonsignificant t value.

The principal hypothesis of the investigation concerned the predicted difference on post-test performance in favor of the classes taught by the teachers rather than the nonteachers. The next analysis involved a comparison of post-test performance of the teacher and nonteacher classes. Initially, the correlation between the pairs was calculated and because of its magnitude, that is, .60, again a correlated t model was used for contrastive purposes. In Table 4 the means, standard deviations, and correlated t test result for the post-test performance of the auto mechanics teacher and nonteacher classes are presented.

Table 4. Means, Standard Deviations, and Correlated t Test Result for Post-Test Performance of Auto Mechanics Teacher and Nonteacher Classes

	n	$\bar{X}$	s	t
Teacher	28	48.16	6.5	1.42
Nonteacher	28	46.53	6.8	

As can be seen, the predicted hypothesis was not confirmed. The difference between the teacher and nonteacher classes on the post-test, a post-test based on the pre-specified objectives which both groups were instructed to accomplish, yielded no significant difference in favor of the teacher group.

In addition to using the gross post-test results as the criterion for testing the validation hypothesis, several other potential ways of looking at the criterion performance were employed. For example, we calculated a gain score on the basis of post-test minus pre-test results. We also looked at a gain score based on the difference between only those items in the post-test which were present in the pre-test. (This "common items" gain score was, incidentally, used in a progress report[6] of this project at the 1968 meeting of the California Educational Research Association.) In addition, other adjusted gain scores were calculated based on an individual's pre-test potential to improve. These "efficiency" scores, along with all other ways of looking at criterion results, confirmed the general result presented in Table 4, namely, there was no significant difference in the performance of the two groups.

Because of the possibility that one of the two groups had been disadvantaged as a consequence of systematic favoritism on relevant variables, an analysis of covariance was computed in which the aforementioned measures of (a) pupils' pre-test scores (on the 20 item test) and (b) pupils' expressed interest in auto mechanics (1 = low to 5 = high) were used as control covariates. Results of this analysis are presented in Table 5.

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[6] Popham, W. J. Progress Report: Performance Tests of Teaching Proficiency in Vocational Education, 46th Annual Conference, California Educational Research Association, Oakland, California, March 15-16, 1968.

Table 5. Analysis of Covariance of Auto Mechanics Classes (Teachers Versus Nonteachers) Post-Test Performance, using Pre-Test Scores and Pupils' Expressed Interest in Auto Mechanics as Covariates.

Source	df	SS	MS	F
Between	1	22.7	22.7	.84
Within	52	1405.6	27.0	
Total	53	1428.3		

	Control Variables		Criterion Variable	
Group	Pre-Test $\bar{X}$	Interest $\bar{X}$	Unadjusted Post-Test $\bar{X}$	Adjusted Post-Test $\bar{X}$
Teachers	9.8	3.6	48.16	47.99
Nonteachers	9.7	3.6	46.53	46.71

As can be seen from Table 5, results of the analysis of covariance fail to reveal any significant difference between the teachers and nonteachers.

Analysis of variance tests of the difference between affective reactions of pupils, as reflected by responses to the student questionnaire, failed to reveal any significant differences between teacher classes and nonteacher classes. Measures involved in these analyses included responses to such questions as: "After this unit how would you rate your interest in the specific topic of carburetion?"

In summary, although a number of other analyses were conducted for heuristic purposes, the primary analyses reveal rather graphically that, contrary to prediction, the performance of the experienced auto mechanic teachers was not significantly superior to that of the nonteachers who were instructing comparable students.

Electronics. The initial analysis conducted was the determination of means and standard deviations for each of the classes taught by the 16 electronics teachers and the 16 nonteachers. Results of these computations for pre- and post-test performance of the electronics classes are presented in Table 6.

Table 6. Class Pre- and Post-Test Means and Standard Deviations of 16 Electronics Teacher and Nonteacher Pairs

	Pre-Test			Post-Test		
	n	$\bar{X}$	s	n	$\bar{X}$	s
Teacher	8	8.2	3.3	6	33.3	9.4
Nonteacher	7	5.8	2.2	7	28.4	5.1
Teacher	20	7.2	2.7	21	19.1	7.6
Nonteacher	18	7.6	2.9	16	20.7	4.9
Teacher	15	4.0	2.8	22	19.4	4.7
Nonteacher	17	5.4	2.4	18	20.0	3.8
Teacher	21	7.7	3.2	22	33.0	7.3
Nonteacher	19	6.7	2.4	23	28.9	7.2
Teacher	25	5.9	3.1	26	28.5	9.1
Nonteacher	26	6.4	2.7	25	24.0	8.5
Teacher	23	7.4	2.6	21	23.0	7.6
Nonteacher	21	7.3	2.4	22	20.0	4.4
Teacher	16	6.5	2.0	17	19.7	5.5
Nonteacher	16	5.4	2.1	14	17.5	3.0
Teacher	18	6.0	1.5	19	23.2	5.5
Nonteacher	23	5.6	2.9	21	23.6	7.8
Teacher	27	7.0	2.1	26	23.2	6.2
Nonteacher	27	8.3	2.9	27	27.6	7.6
Teacher	23	9.2	3.2	22	23.3	9.5
Nonteacher	22	7.7	2.7	19	22.2	5.8
Teacher	18	3.8	2.1	20	17.1	5.5
Nonteacher	24	5.0	2.0	26	17.6	3.9
Teacher	14	8.0	2.3	13	24.3	6.0
Nonteacher	7	9.4	3.8	9	25.2	7.8
Teacher	24	8.8	4.0	26	27.6	7.6
Nonteacher	23	7.8	2.7	20	26.9	9.6
Teacher	25	7.9	3.1	25	25.0	8.6
Nonteacher	27	7.5	2.4	26	20.4	6.8
Teacher	21	6.8	2.2	20	24.6	5.0
Nonteacher	23	8.5	3.5	23	21.1	7.5
Teacher	24	6.0	1.8	20	23.4	5.8
Nonteacher	24	5.2	2.2	25	17.6	4.3

Several preliminary analyses were then conducted. The first of these was a calculation of internal consistency (Kuder-Richardson 20) coefficient for the pre- and post-tests. These were calculated on the basis of the entire sample of pupils considered irrespective of (a) class and (b) whether or not they were taught by a teacher or a nonteacher. The actual number of such pupils was approximately 700. The Kuder-Richardson 20 coefficient for the pre-test was .58 and for the post-test was .62.

As in the analysis of the auto mechanics data, intercorrelation matrices were computed in which the post-test results were correlated with a number of variables potentially useful as covariates for the anticipated analysis of covariance. As in the case of the auto mechanics data, the most useful covariates appeared to be (a) pre-test scores and (b) pupils' expressed interest in the field of electronics. The correlations based on class means yielded an $\underline{r}$ of .47 between pre- and post-test scores, an $\underline{r}$ of .78 between post-test and expressed interest, and an $\underline{r}$ of .62 between pre-test and expressed interest.

The next analysis compared pre-test performance of the teacher and nonteacher classes. Because of the potential similarity of performance of pairs of classes, a product-moment correlation coefficient was first calculated to determine the degree of relationship between the teacher and nonteacher pre-test means on the basis of school. The correlation in this instance was .64. Because of this relationship, a correlated $\underline{t}$ test model was employed to test for significance or difference between the pre-test means of the teacher and nonteacher classes. In Table 7 the means, standard deviations, and correlated $\underline{t}$ test result for pre-test performance of the 16 electronics teacher and the 16 nonteacher classes are presented.

Table 7. Means, Standard Deviations, and Correlated $\underline{t}$ Test Result for Pre-Test Performance of Electronics Teacher and Nonteacher Classes

	n	$\overline{X}$	s	$\underline{t}$
Teacher	16	6.9	1.5	.05
Nonteacher	16	6.8	1.3	

As can be seen from inspection of Table 7, the pre-test means of the two groups were almost identical. The correlated $\underline{t}$ test yielded a nonsignificant $\underline{t}$ value.

The main hypothesis of the investigation concerned the predicted difference on post-test performance in favor of the classes taught by the teachers rather than the nonteachers. The next analysis involved a comparison of post-test performance of the teacher and nonteacher classes. Initially, the correlation between the pairs was calculated and because it was of some magnitude, that is, .76, again a correlated $\underline{t}$ model was used for contrastive purposes. In Table 8 the means, standard deviations, and correlated t test result for the post-test performance of the electronics teacher and nonteacher classes are presented.

Table 8. Means, Standard Deviations, and Correlated t Test Result for Post-Test Performance of Electronics Teacher and Nonteacher Classes

	n	$\overline{X}$	s	t
Teacher	16	24.26	4.5	2.0
Nonteacher	16	22.70	3.8	

As can be seen, the predicted hypothesis was confirmed. The difference between the teacher and nonteacher classes on the post-test, a post-test based on the pre-specified objectives which both groups were instructed to accomplish yielded a small, but significant difference in favor of the teacher group. The mean of the teachers was 24.26 and the mean of the nonteachers was 22.70. The difference was significant, using a one-tailed test, at the .05 level.

In addition to using the gross post-test results as the criterion for testing the validation hypothesis, several other potential ways of looking at the criterion performance were employed. These were identical to the schemes employed in the analysis of auto mechanics criterion performance. Most of these criterion performance estimates confirmed the general result depicted in Table 8, namely, a modest difference in favor of the teacher groups.

Because of the possibility that one of the two groups had been disadvantaged as a consequence of systematic favoritism on relevant variables, an analysis of covariance was calculated in which the aforementioned measures of (a) pupils' pre-test scores (on the 17 item test) and (b) pupils' expressed interest in electronics (1 = low to 5 = high) were used as control covariates. Results of this analysis are presented in Table 9.

Table 9. Analysis of Covariance of Electronics Classes (Teachers Versus Nonteachers) Post-Test Performance, using Pre-Test Scores and Pupils' Expressed Interest in Electronics as Covariates

Source	df	SS	MS	F
Between	1	5.3	5.3	.72
Within	28	205.9	7.3	
Total	29	211.2		

	Control Variables		Criterion Variable	
Group	Pre-Test $\bar{X}$	Interest $\bar{X}$	Unadjusted Post-Test $\bar{X}$	Adjusted Post-Test $\bar{X}$
Teachers	6.9	3.6	24.26	23.89
Nonteachers	6.8	3.5	22.70	23.07

As can be seen from Table 9, the analysis of covariance "washed out" the significant difference between the groups. The adjusted means are extremely similar and the resulting F value of .72 was not statistically significant.

Analysis of variance tests of the difference between affective reactions of pupils, as reflected by responses to the student questionnaire, failed to reveal any significant differences between teacher classes and nonteacher classes. Measures involved in these analyses included responses to such questions as: "After this unit how would you rate your interest in the specific topic of electronics?"

In summary, although a number of other analyses were conducted for heuristic purposes, the primary analyses yielded mixed results regarding criterion performance of the teacher and nonteacher groups. While the correlated t test yielded a one-tailed statistically significant result, the analysis of covariance failed to confirm this difference. The disparity in results is due, of course, to the initial differences on the covariates favoring the teacher group.

DISCUSSION

In looking over the results of two efforts to confirm the initial validation prediction that experienced teachers would be able to outperform nonteachers with respect to the attainment of pre-specified objectives, one might easily become discouraged. The prediction was not borne out by the data. Yet, the same results had been encountered once before with respect to tryout of the previously described Social Science Performance Test. Thus, the investigator is more prepared for the findings. Indeed, having already completed the Social Science

Performance Test Project and interpreted its results in a particular way, it would have been perplexing to have the validation prediction, made several years ago, actually confirmed. Because of the earlier results of the Social Science study, the investigator was in a rather unusual position of "pulling" for nonsignificant differences. It is hoped the reasons for this can be made clear.

The position was taken in the discussion of the Social Science Performance Test results that it was probably naïve to anticipate that experienced teachers would be better able to accomplish behavior changes in learners than nonteachers. The reasons for this were several. In the first place, teachers are not systematically trained to be changers of pupil behavior. Their teacher preparation experiences focus on a variety of other kinds of activities, but rarely address themselves to the question of how pupil growth can be systematically promoted. Further, few teachers are consistently reinforced by their administrators, school system, or community for being particularly skilled in modifying pupil behavior. In other words, the whole educational system, as it is currently set up, does little to foster the experienced teacher's skill in promoting pupil behavior changes. In essence, the experienced teacher is simply not more experienced at modifying learner behavior. This is an unfortunate state of affairs.

One might quickly conclude, and quite erroneously, that performance test approaches to the assessment of teacher competence cannot be validated through approaches such as that described herein and, therefore, should not be employed as indices of teacher competence. This could not be farther from the truth. There has been enough written through the years to support the general conception that the ultimate index of a teacher's proficiency _must_ be his ability to modify his learners. This is his _raison d'etre_ in the classroom. If pupils do not leave a teacher's classroom markedly modified in important ways, the teacher has been unsuccessful, no matter how rhapsodic his lectures, no matter how insightful his discussions, no matter what merit his administrator believes his classroom procedures to possess. This leads to the conclusion that a performance test measure of teacher effectiveness should be, indeed, the _only_ legitimate index of teaching proficiency.

This may suggest that the next step in validating this general assessment approach is to provide both training and, subsequently, significant reinforcers for a group of teachers who would become proficient in bringing about pupil behavior changes. These teachers can be pitted against a group of nonteachers, or for that matter, even teachers who have not been so trained and who have not been, over a period of time, reinforced for modifying learner behavior. The prediction then would be similar to that made several years ago, that the teacher who is demonstrably skilled in modifying behavior of learners should be able to manifest that superiority in other performance test situations.

Another alternative exists, however. Perhaps we should establish the legitimacy of performance tests measures of teacher proficiency by fiat. Maybe we should simply assert that this is the only acceptable measure of instructional effectiveness, and then move immediately to the manipulation of treatment variables which we hope can produce better results on such performance test measures. In other words, the original position of the writer was that we should, for the moment, circumvent the identification of powerful treatment variables in order that we could demonstrate graphically the validity of performance test measures of teaching skill. It may be more suitable to actually reverse this strategy and skip the validation phase of the research program. In other words, it may not be worth the trouble to validate these performance tests. The writer certainly believes it is possible to demonstrate their validity, but perhaps under the press of today's educational needs, there may be some merit in jumping ahead to the identification of powerful treatment variables.[7]

Having lived with performance tests and related considerations for several years now, the writer concludes the report with a reaffirmation of commitment to these measures as desirable ways of assessing teaching skills. The general strategy employed represents the epitomy of an ends-oriented rather than a means-oriented approach to instruction. As such, performance test measures seem to be the most servicable of those currently available to educators who require legitimate indices of teaching proficiency.

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[7] The writer is indebted to Richard Schutz, Director of the Southwest Regional Laboratory for Educational Research and Development, for suggesting this alternative.

APPENDIX A

INSTRUCTIONAL UNIT, CARBURETION

INSTRUCTIONAL UNIT, CARBURETION

Experimental Version III

June, 1966

INTRODUCTION

You will be participating in an experimental trial of a new teaching unit on the topic of carburetion. We are attempting to see how effectively teachers can accomplish the instructional objectives presented in this unit. To help us perform this trial, we ask you to observe a few guidelines. First, read the content outline. This will give you an overall idea of what the unit covers. Next, read the list of specific objectives very carefully. This is important, because they will describe precisely what your students must learn. Always remember to refer to the specific objectives when you are in doubt as to what you are supposed to teach.

The exact procedure of our experiment is this. First, a member of our staff will visit your class before you begin the unit. He will administer a short test, using test items based explicitly on the objectives you have been given. The results of this pre-test will indicate how much your students know about carburetion before they actually start the unit. Then you will teach the unit, taking not more than ten hours. Of course, you may not need that much time, but this will be the maximum time allowed. After the unit has been taught, we will once more send a representative to your class. Again he will administer a test, based exclusively on the objectives for the unit. This final test will be somewhat longer, in order to obtain a more thorough measurement of the attainment of the class. After that, we will welcome any comments, suggestions or criticisms you may wish to make with regard to the unit, the objectives, or any other aspect of this project.

Other than the time limitation of ten instructional hours, there is only one rule which we ask you to follow: Teach to the objectives given in this unit. We recognize that you may have different preferences regarding objectives for a unit on carburetion. However, for purposes of the experiment please try your best to accomplish the objectives given here. After the unit has been completed we shall seek your judgment regarding the value of the various objectives. But for this trial, please plan your teaching in order to achieve the student behaviors outlined in this unit. Therefore, you will want to adopt a plan that will most efficiently teach those skills, abilities, etc., to your students.

We recognize that some things can be taught which are not covered in our objectives. Goals involving values and attitudes are very important, and cannot be overlooked. However, these kinds of teaching goals are very difficult to observe, especially in the short time we have. Therefore, we have purposely limited our objectives to only those which call for a readily observed behavior on the part of the student. It is the attainment of these behaviors stated in our objectives that we are interested in and testing for. As a teacher, you know that instilling in your students an appreciation for proper use of tools, for instance, is a worthy teaching goal. But it lies outside the scope of this experiment. We are not suggesting that you forget about such goals. We simply ask you to emphasize the skills, etc., that are outlined in the objectives described a few pages later.

CONTENT OUTLINE

Following is a general outline of the different topics included in this unit on carburetion. The organization is not arbitrary. However, neither is it the only way to approach the subject. It is not designed as a basis for your teaching plan, although you are perfectly free to use it as such. Rather, it is to familiarize you with the areas covered by the unit's objectives. The headings used here will be the key to the resource unit which follows the list of objectives, enabling you to orient yourself when using the reference materials.

A. Theory of Carburetion.

1. What the carburetor does (principles of carburetion).
2. Basic configuration of the carburetor.
3. Air to fuel ratios.

B. The Fuel System as a Whole.

1. Fuel filters.
2. Fuel pump.
3. Air cleaners.
4. Intake manifold.

C. The main Systems of the Carburetor.

1. Float system.
2. Idle and low speed system.
3. Main fuel system.
4. Power system.
5. Accelerator pump system.
6. Choke system.
7. Other units or parts
    - (a) choke unloader
    - (b) venturi
    - (c) idle vapor valve
    - (d) antistall dashpot
    - (e) multiple barrel carburetors

D. Troubleshooting (malfunctions, plus their causes and cures).

1. Hard starting.
2. Stalling when accelerator is suddenly released.
3. Rough idle and stalling.
4. Poor low speed operation.
5. Faulty acceleration.
6. Surging (cruising to top speeds).
7. Reduced top speed.
8. The likely causes of the above mentioned malfunctions.
9. The cures for the above mentioned malfunctions.

UNIT OBJECTIVES

In this section the instructional objectives for the unit are presented. As stated earlier, please use any instructional technique you wish to achieve them, but design your teaching to accomplish as many of these objectives as you can in the time allowed to you. The content outline headings will be repeated here, each one followed by the objective or objectives appropriate to it. (Information regarding particular parts and functions of the carburetor in relation to these objectives can be found in the resource unit.)

A. Theory of Carburetion

1. The student will select from a series of multiple choice alternatives that one which most accurately describes or explains each of the following:
   a. The term carburetion.
   b. Air flow through the carburetor.
   c. The processes of atomization and vaporization.
   d. The effect of the venturi on air flow through the carburetor.
   e. Vacuum action as found in the carburetor.
   f. The role of heat in carburetion.

2. Given a diagram of a simple one barrel carburetor, the student will locate each of the following parts:
   a. Venturi
   b. Float bowl
   c. Float
   d. Float needle valve
   e. Discharge nozzle
   f. Throttle valve
   g. Choke valve
   h. Choke poppet valve
   i. Choke thermostat
   j. Main metering jet
   k. Power valve
   l. Idle vapor vent

3. a. The student will match driving conditions, and different air pressures (as found at different altitudes), with the air to fuel ratios appropriate to them.
   b. The student will choose the alternative that states the modification that should be made in the carburetor when driving at different altitudes.

B. The Fuel System as a Whole

4. The student will select from a list of fuel filters those which can be cleaned and used again.

5. The student will select from a series of alternatives that one which describes:
   a. Proper fuel line installation procedure (metal lines).
   b. Proper fuel pump delivery measurement procedure.

6. The student will match the names of the three main types of air cleaner with descriptions of those types.

7. The student will select from a list of alternative descriptions the one which most accurately describes the functions of the intake manifold.

C. The Main Systems of the Carburetor

8. The student will choose from lists of possible definitions those which most accurately describe the main parts of the float system, which are:
   a. Float
   b. Float bowl
   c. Float bowl needle valve

9. Given alternative descriptions of float system function, the student will choose the one which most accurately describes that function.

10. The student will choose from a list of possible definitions those which most accurately describe the main parts of the idle/low speed system, which are:
    a. Idle fuel passages
    b. Idle air bleed
    c. Idle discharge ports
    d. Idle adjusting needle valve.

11. The student will read a description of idle/low speed operation and then select the alternative that best states whether the description is accurate or inaccurate (and, if inaccurate, why).

12. The student will identify which of five statements does not describe one of the four accepted ways of adjusting engine idle.

13. The student will match definitions of the principal parts of the the main fuel supply systems with the respective names of those parts, which are:
    a. Main metering jet
    b. Main well
    c. Discharge tube
    d. Main air bleed
    e. Fuel discharge nozzle

14. The student will read a description of main fuel supply system operation, and will then choose the alternative which best states whether the description is accurate or inaccurate (and, if inaccurate, why).

15. The student will match the correct names of the two basic types of power system designs with descriptions of those types. The two basic designs are:
    a. Power valve
    b. Step-up rod

16. Given a description of power system function, the student will select the alternative which best states whether the description is accurate or inaccurate (and, if inaccurate, why).

17. The student will identify which of several alternatives most accurately describes accelerator pump function.

18. Given a description of accelerator pump linkage adjustment procedure, the student will select the alternative which best states whether the description is accurate or inaccurate (and, if inaccurate, why).

19. The student will choose the correct definition of the basic parts of the choke system, which are:
    a. Choke shaft
    b. Choke valve
    c. Choke poppet valve
    d. Manual choke control linkage, or automatic thermostat

20. The student will select from a series of alternatives the one which best describes the following systems:
    a. Choke system
    b. Choke unloader
    c. Antipercolator
    d. Anti-stall dashpot
    e. Primary and secondary sections of the four barrel type carburetor.

D. Troubleshooting (The format of objectives 21 through 27 will be the same. The students will be asked to identify the likely causes of these malfunctions in two ways. First, they will have to pick the alternative that lists only possible causes of a particular malfunction. Second, they will have to locate on a diagram which parts of the carburetor would be inspected when trying to find the cause of a certain malfunction).

21. The student will identify these as causes of hard starting:
    a. Incorrect choke thermostat adjustment
    b. Binding choke linkage or plate
    c. Restricted choke vacuum and hot air passages
    d. Air leaks into vacuum and hot air passages
    e. Manifold heat valve stuck

22. The student will identify these as causes of stalling when the accelerator is suddenly released:
    a. Improperly adjusted dashpot
    b. Defective dashpot
    c. Clogged air bleeds or idle passages
    d. Leaking intake manifold and carburetor gaskets

23. The student will identify these as causes of rough idle and stalling:
    a. Improper idle adjustments
    b. Damaged tip on idle mixture screws
    c. Clogged air bleeds or idle passages
    d. Improper fast idle cam adjustment
    e. Damaged idle tubes
    f. Clogged air cleaner

24. The student will identify these as causes of poor low-speed operation:
    a. Idle adjusting screws unequally adjusted
    b. Clogged idle transfer holes
    c. Restricted idle air bleeds and passages
    d. Incorrect float level
    e. Clogged air cleaner

25. The student will identify these as causes of faulty acceleration:
    a. Improper pump stroke adjustment
    b. Inoperative pump discharge check ball
    c. Plugged discharge nozzle
    d. Leather worn or not working properly

26. The student will identify these as causes of surging (from cruising to top speed):
    a. Clogged main jets
    b. Undersize main jets
    c. Low fuel level
    d. Low fuel pump pressure or volume
    e. Blocked air bleeds
    f. Clogged inlet filter screen or fuel in-line filter

27. The student will identify these as causes of reduced top speed:
    a. Low fuel pump volume
    b. Clogged power system fuel passage to main well
    c. Power valve stuck
    d. Improper power valve or obstructed main jets
    e. Faulty choke operation
    f. Clogged air cleaner

28. The student will be able to identify which of a list of possible operations would correct any one of the particular malfunctions listed in objectives 21 through 27. Following the name of the malfunctions will appear the list of possible cures. From this list the student will select the ones that might help. (See page 38 in resource unit for a list of these cures.)

29. The student will select from a list of alternatives the likely result of outcome of the following conditions:
    a. Water in the gas tank above the level of the gas tank filter
    b. A leaking float in the carburetor
    c. Oversize metering jet
    d. Fuel pump that delivers too little fuel
    e. Defective anti-stall dashpot
    f. Clogged or restricted idle passages
    g. Clogged or obstructed main jets
    h. Faulty choke operation (choke will not open and close when it should; stuck or sticking plate, etc.)
    i. Air cleaner too tightly tightened on the air horn
    j. Manifold heat control valve not operating properly

RESOURCE UNIT

You have now read the content outline and list of specific objectives. What you must teach is contained therein.

This resource unit is divided into two parts. The first contains definitions of parts, descriptions of functions, and terminology. Its purpose is to familiarize you with the language we use, and the boundaries put on each content area. For example, we use the term system to describe the functions of the various parts of the carburetor, rather than the terms circuits or units as found in other resource materials. However, our usage of these terms is consistent and for your easy understanding.

The second part contains possible learning activities. You may use some, all, or none of them as you see fit. How you teach the unit is up to you. We offer these activities as possibilities only.

The second part of the resource unit, as the first, follows the headings of the content outline. Each specific part or system has its own section. The sections are designated by the name of that particular part or system, e.g., float system. All possible learning activities are denoted by the word "activity."

PART I: DEFINITIONS OF PARTS, DESCRIPTIONS OF FUNCTIONS, TERMINOLOGY

Theory of Carburetion

Carburetion

Carburetion is defined as the mixing of air and fuel to form a vapor suitable for combustion. The ratio of air to fuel varies according to the particular driving conditions.

Vacuum Action

Vacuum action in the carburetor is movement of air and fuel through the carburetor and into the intake manifold due to a vacuum created by the difference in air pressure between the outside air and the combustion chamber.

Air to Fuel Ratios
(Figuring both by weight)

The ratio of air to fuel used varies according to varying driving conditions. Approximate ratios are these:

8/1........A rich mixture used when starting a car, especially during cold weather.
15/1.......Normal cruising ratio for altitudes under about 3,000 ft.
17/1.......A slightly leaner mixture used at altitudes above 3,000 ft. (By weight, the ratio should still be 15/1 if the right metering jet is used; the weight ratio would probably be more like 17/1, due to the thinner air.)

The ratio is changed by replacing the larger, low altitude jets with smaller, high altitude jets.

Configuration of the Carburetor

Types of carburetor design: these types are 1) the air vane, 2) air valve (both up and down draft), 3) rotary valve, and 4) plain tube (both up and down draft).

The Fuel System as a Whole

Summary of the Fuel System

The fuel system includes the gasoline tank, fuel lines, fuel filters, fuel pump, air cleaner, carburetor, and intake manifold. While all of these parts of the fuel system but the carburetor and intake manifold are in a sense outside our specific area of study, it is still crucial that the student receives a sort of overview of understanding of the fuel system in its entirety.

Fuel Line Installation (Metal Lines)

Proper procedure entails the use of two wrenches of the correct size, replacement of the line in exactly the same position, and avoidance of any bending or twisting of the line.

Fuel Pump

The fuel pump is the most important part of the fuel system outside of the carburetor. The chief types of fuel pumps are: 1) mechanical diaphragm, 2) combination fuel and vacuum pump, 3) electric type.

Fuel Pump Delivery Measurement

Measurement of fuel pump delivery is concerned with two things, volume and pressure. The precise specifications vary with each carburetor. Both pressure and volume are important when determining whether or not a fuel pump is operating normally.

Types of Air Cleaners

The three main types of air cleaners are the dry type, oil bath type, and oil wetted mesh type. Overall, the most efficient type is the dry paper fiber air cleaner. The air cleaner, besides its obvious function, also serves as a silencer and a back fire preventing device.

Intake Manifold

The functions of the intake manifold are these: a) transfer of air/fuel mixture from carburetor to combustion chamber; b) additional vaporization of the air/fuel mixture through heating.

The Main Systems of the Carburetor

Float System

The main parts of the float system are the float bowl, float, and needle valve assembly.

Idle Low Speed System

The important parts of the idle/low speed system are: idle fuel passages, idle air bleed, idle discharge ports, idle adjusting needle valve.

Engine Idle Adjustment

The four accepted methods of adjusting engine idle: 1) the idle adjusting needle valve should be set according to factory specifications. 2) idle can be set by setting the adjusting valve at the point which yields the smoothest sounding idle (i.e., tuning by ear), 3) idle can be set by setting the adjusting valve at the point which yields the highest steady vacuum reading on a vacuum gauge, 4) idle can be adjusted by setting the needle valve at the point which yields the highest r.p.m. reading on a tachometer, 5) idle must (on some models, e.g. Chrysler with its clean air package) be set through reading exhaust gas analysis.

Main Fuel Supply System

The main parts of the main fuel supply system are the main metering jet, main well, main air bleed, discharge tube, and fuel discharge nozzle.

Power System

The two main types of power system designs are the step-up rod and the power valve. Power system function here refers to the general principle of an added amount of fuel (and hence a richer mixture) during periods of great stress on the engine. This is accomplished by either the step-up rod or valve, activated by a decrease in the vacuum created in the engine. Because the power valve setup is so common, a teacher may want to give the student the additional information concerning it. There are three subcategories of power valves: 1) actuated by separate piston, 2) actuated by separate diaphragm, 3) self-contained unit.

Accelerator Pump

The two types of accelerator pump are the plunger type and diaphragm type. Both types are actuated by a throttle linkage, squirting an additional amount of fuel into the venturi during rapid acceleration.

Choke System

The main parts of the choke system are the choke valve, choke shaft, choke breather valve, manual choke control linkage or automatic choke thermostat, and housing.

Choke Unloader

When the accelerator is fully depressed, a tang on the throttle arm contacts an arm or kick lever on the fast idle cam. This causes the choke valve to open to prevent flooding.

Idle Vapor Vent (or Float Bowl Vent)

The idle vapor vent can be defined as the device designed to prevent undue vapor pressure from building up in the float bowl. When the accelerator pedal is released, a linkage opens the valve, letting the vapor escape.

Anti-stall Dashpot

The anti-stall dashpot prevents the engine from stalling due to a sudden closing of the throttle valve when the accelerator is suddenly released. To accomplish this, the dashpot uses a device which causes the throttle valve to push against either a quantity of air, or against a spring, as it closes. In this way, the throttle valve closes more slowly.

Multiple Barrel Carburetors

Multiple barrel carburetor design and operation: Of the various systems and parts of the carburetor, only the air horn, choke and accelerating system are found singly, regardless of number of barrels. In the four barrel carburetor, the primary side performs the normal carburetor functions, while the secondary side provides an extra amount of air/fuel mixture during periods of great stress on the engine, or during rapid acceleration. When replacing a single barrel carburetor with a multiple barrel carburetor, it is necessary to use the correct design of manifold and plate.

Troubleshooting

A precise list of the various malfunctions to be dealt with, plus their probable causes, can be found in objectives 21 through 28 (a series of conditions which can produce malfunctions is found in objective 29). Following is a list of the operations that could help correct those malfunctions.

1. Hard starting
    a. Adjust choke thermostat.
    b. Repair or replace defective parts.
    c. Remove carburetor and clean choke passages and blow out with compressed air.
    d. Replace defective gaskets or heat tube.
    e. Manifold heat control valve stuck; free or replace.

2. Stalling when accelerator is released suddenly.
    a. Make all idle adjustments.
    b. Replace dashpot.
    c. Remove and clean carburetor with solvent and compressed air.
    d. Replace leaking gaskets.
    e. Check air cleaner, may be clogged.

3. Rough idle and stalling.
    a. Make all idle adjustments.
    b. Replace missing screws.
    c. Clean carburetor with solvent and compressed air.
    d. Adjust throttle stop screw.
    e. Adjust fuel level.
    f. Remove and inspect idle tubes.
    g. Check air cleaner, may be clogged.

4. Poor low-speed operation.
    a. Make all idle adjustments.
    b. Remove and clean carburetor with solvent. Blow out passages with compressed air.
    c. Check air cleaner, may be clogged.

5. Faulty acceleration.
    a. Adjust pump strokes.
    b. Clean or replace.
    c. Clean nozzle and blow out with compressed air.
    d. Replace gasket.
    e. Check and if necessary replace pump check ball.
    f. Check air cleaner, may be clogged.

6. Surging (cruising speeds to top speeds).
    a. Clean main jets with solvent and blow out jets with compressed air.
    b. Replace main jets.
    c. Adjust fuel level.
    d. Test fuel pump.
    e. Clean air bleeds with solvent and blow out with compressed air.
    f. Clean inlet screen with solvent and blow out bleeds with compressed air.
    g. Check jets for tightness.

7. Reduced top speed.
    a. Test fuel pump.
    b. Clean carburetor with solvent and blow out passage with compressed air.
    c. Replace power valve.
    d. Replace main jets.
    e. Check choke operation. Plate may not be fully open.
    f. Clean or replace air cleaner.

PART II: POSSIBLE LEARNING ACTIVITIES

It is important to remember that this portion of the unit contains learning activities that you may or may not use, at your own discretion. The ultimate decision as to how you wish to attain in your students the behaviors in our objectives is yours. We offer these learning activities only as possibilities.

Theory of Carburetion

Basic Principles of Carburetion

Because the basic principles of carburetion are so important, teachers may want to devote time to them in the classroom. Vacuum action, air flow through the carburetor, and venturi design can be put together in one section, while heat, atomization and vaporization can be dealt with at the same time.

Internal Combustion Power

Activity: The action of expanding hot gases upon the piston can be shown in a diagram of the type on the next page. Since forward motion is the reason for the motor car, and since internal combustion is the motive force, a teacher of carburetion may want to teach something about that principle (internal combustion). As a practice test, students can be asked to write a brief description of the workings of internal combustion power as found in the automobile engine. The teacher can determine from this just what misunderstanding or problems on the part of the students need to be corrected.

Vacuum Action or Pressure Differentials, Air Flow through Carburetor and Venturi Design

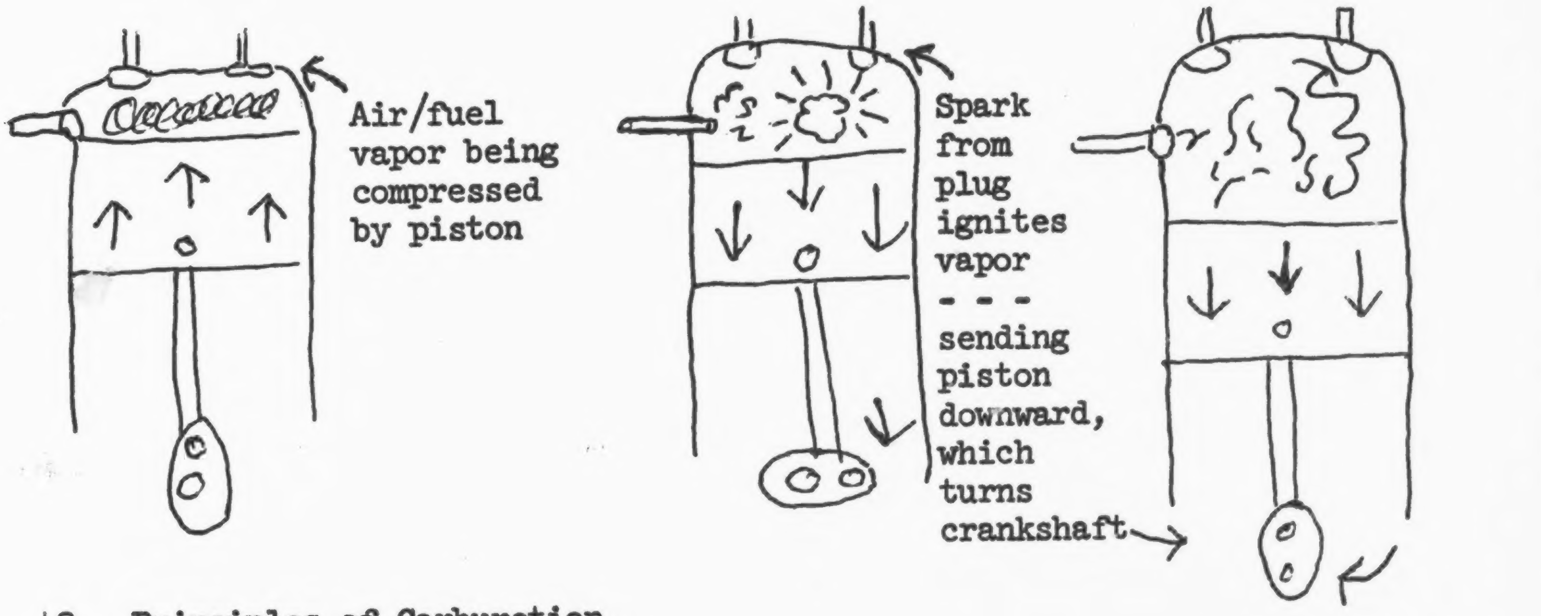
Activity: A possible introduction to vacuum action, venturi design and air flow, can be the use of diagrams, such as can be found on the next page. The best diagrams are probably those which show air and fuel as two different colors. The teacher might indicate the difference in pressure between the combustion chamber and the outside air at this time.

Activity: After the preliminary explanation of vacuum-created air flow, a short quiz can be administered to make sure that the basic idea is understood.

Sample questions:

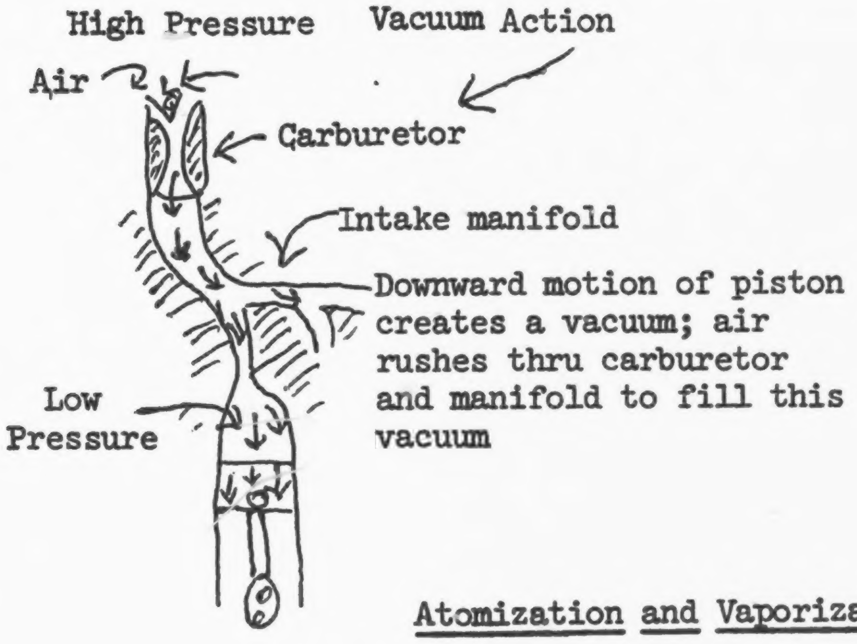
a. Where is the air pressure greater, in the combustion chamber, or in the outside air? Ans. - outside air.
b. What is the cause of air flow in the carburetor? Ans. - vacuum action.

I. Internal Combustion

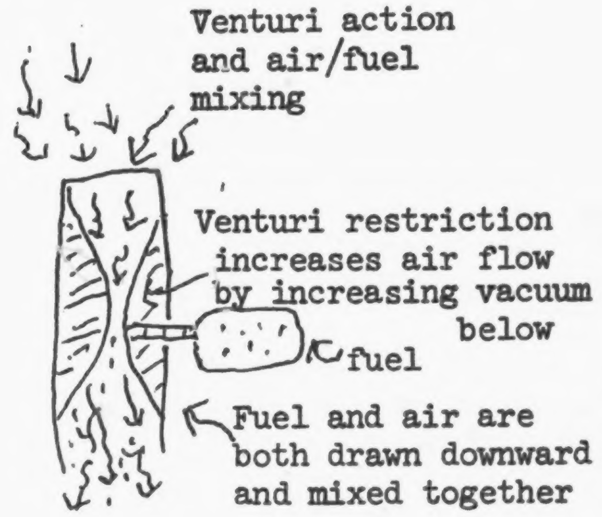

Air/fuel vapor being compressed by piston

Spark from plug ignites vapor - - - sending piston downward, which turns crankshaft

2. Principles of Carburetion


High Pressure
Vacuum Action
Air
Carburetor
Intake manifold
Low Pressure

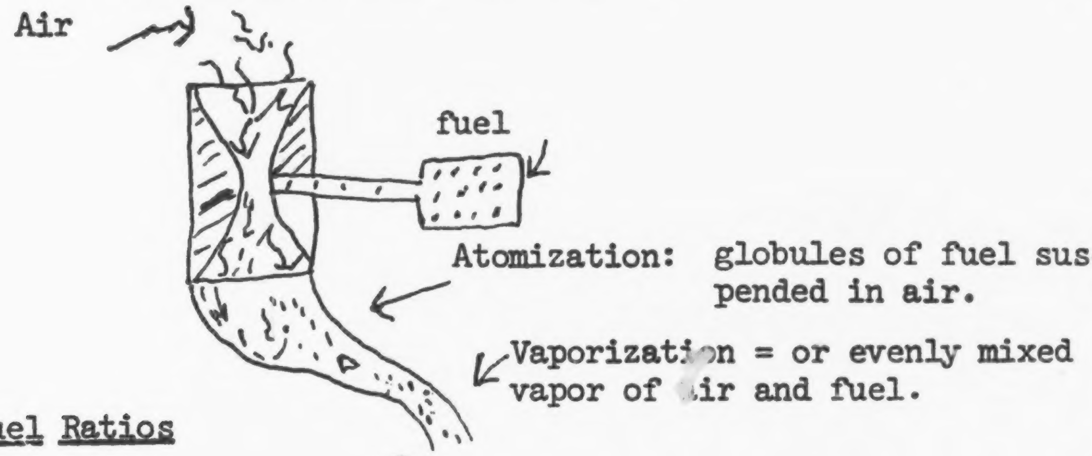
Downward motion of piston creates a vacuum; air rushes thru carburetor and manifold to fill this vacuum


Venturi action and air/fuel mixing

Venturi restriction increases air flow by increasing vacuum below

Fuel and air are both drawn downward and mixed together

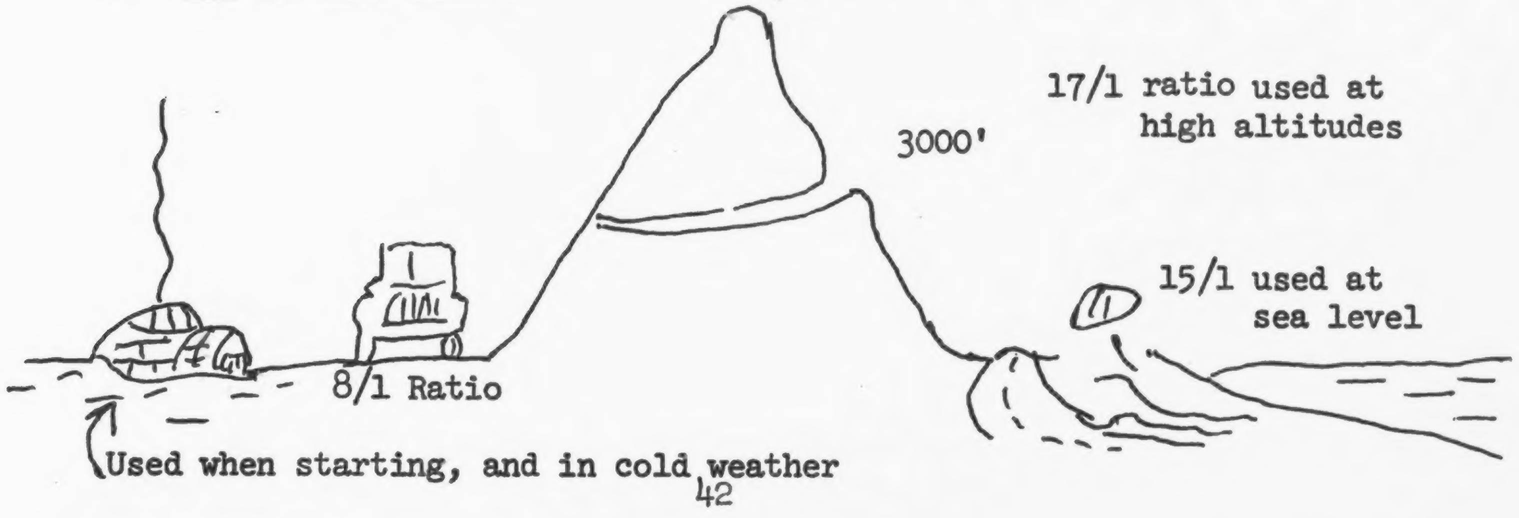
Atomization and Vaporization



Atomization: globules of fuel suspended in air.

Vaporization = or evenly mixed vapor of air and fuel.

3. Air to Fuel Ratios



17/1 ratio used at high altitudes

15/1 used at sea level

8/1 Ratio

Used when starting, and in cold weather

Activity: Further demonstrations of the various vacuum actuated parts (power valve, automatic choke) can make use of diagrams that illustrate those parts. Next to vacuum action, vaporization is the most important principle of carburetion. Here is where a diagram showing air and fuel in different colors can be particularly useful. Such a diagram, combined with a thorough explanation, can demonstrate how fuel and air are mixed. To teach the difference between atomization and vaporization, another diagram is probably needed. This one can first show air and fuel mixing in the venturi, with the globules of fuel plainly visible in the air vapor. A further portion might show a uniform mixture of the two colors to indicate the uniform nature of the air/fuel vapor as it enters the combustion chamber.

After each new idea or principle has been introduced, the teacher can formulate many questions regarding the new material. These questions, when given to the students as review tests, can help the teacher achieve his goals.

Basic Carburetor Configuration

Activity: After the basic principles of carburetion have been introduced, the students may want to know the exact details of the process of mixing air and fuel in the carburetor. To do this, a thorough study of the basic design of the carburetor can be helpful. First of all, the teacher can introduce the various carburetor designs.

Activity: It may be helpful to use illustrations of all four types of carburetors. The teacher should point out the basic features of each type, again using appropriate diagrams.

Activity: In the following items are some questions which may be used when checking the students' comprehension of the characteristics of the basic types of carburetors.

Examples:
Air vane type:
a. How many principle systems are there in the air vane carburetor?
   Ans. - 2; main metering system and auxiliary system.
b. In what position are the vanes during choking?
   Ans. - closed.

Air valve type:
a. During which driving condition is the air valve wide open?
   Ans. - acceleration
b. Why is the throttle valve located at the upper end of the barrel?
   Ans. - because the air valve type is an updraft carburetor, with the air intake from below.

Rotary Valve:

a. In which position is the rotary throttle during high speed operation?
   Ans. - straight up and down.
b. During half open throttle position, which part delivers the fuel into the main passages?
   Ans. - the spray tube.

Plain tube:

a. What constricts the air passage during starting?
   Ans. - the choke plate
b. What is the constricted part of the main barrel called?
   Ans. - the venturi.

Activity: The teacher can hand out copies of a simple diagram of a plain tube carburetor. After an introductory session concerning specific explanations of the basic parts and systems, the teacher can ask the students to label the various parts, etc. This is a simple test of the students' knowledge of the location of the basic parts of the plain tube carburetor.

Air to Fuel Ratios

Activity: The teacher may display appropriate illustrations and explain why each ratio is used at a particular altitude, or under special circumstances (i.e., when starting the engine). Then, after the explanation has been given, and any questions answered, the teacher removes the poster and gives a quick quiz, requiring the students to write the correct ratio for each description of a driving condition that he states (i.e., what ratio by volume should be used while driving in the mountains of Colorado? Ans. - 17/1 by weight.)

The Fuel System as a Whole

Gas Tank

Activity: Float operated fuel gauge is a feature that can be mentioned when introducing the gas tank as part of the fuel system.

Fuel Filter Cleaning

Activity: Teacher may present one particular step in fuel filter cleaning and ask students to write down which step comes next, e.g., "What step follows flushing tank with solvent?"
Ans. - reconnect fuel line.

Fuel Line Installation Procedure (Metal Type)

Activity: The teacher may first explain the procedure in detail, pointing out the importance of each step. As a quiz, the students can list the various steps on paper.

Activity: For a more complete test, the teacher can read aloud, or place on the board, various descriptions of this procedure. One should be correct, while the other should contain at least one irrelevant or incorrect statement. These need be only a few sentences. If the student consistently picks the correct descriptions, he must know the procedure well. Sample: When replacing a fuel line, a torque wrench should be used. (Irrelevant.)

Activity: The teacher can help his students master fuel line installation by actually performing this operation in a demonstration. The teacher should specifically explain each step as it comes in the sequence. After one or two demonstrations, the teacher can start again, this time calling on different students to tell him what step should come next. As a final activity, as many students as possible should attempt the installation, with appropriate critical comments from the teacher.

Fuel Pump

Activity: To help students learn the exact nature of each fuel pump type, it is useful to have them write descriptions of each type, mentioning each of the unique features.

Activity: A practice test might include questions such as these:

a. Which type of fuel pump contains two diaphragms?
   Ans. - a combination fuel and vacuum pump.
b. Besides mechanical power, what type of power is used in fuel pumps?
   Ans. - electrical power.

Fuel Pump Measurement

Activity: The teacher can explain the factors of fuel pump delivery measurement using either a diagram or a real fuel pump to show how they are checked. As a preliminary test, the students write from memory the basic factors of fuel pump delivery measurement. To add information to the lesson, the teacher can give various specifications for particular carburetors. At a later date, the teacher can name a specific carburetor type and mention a specification. The specification can be accurate or not. If it is inaccurate the students should be able to identify that carburetor as one which is malfunctioning.

Activity: As a more thorough test, the teacher can present various supposed means of delivery measurement, from which the students should choose the one which is correct. The other statements should contain some correct information, but of course will also contain at least one error. Sample: To check delivery of a fuel pump, it is necessary to consider volume. (This is correct.)

Air Cleaner

Activity: The teacher can give detailed descriptions of each type, pointing out the unique features of each. Next, the teacher can allow students to see as many diagrams and pictures of the various types as possible. This will enable the students to identify the three versions readily.

Activity: Practice tests may be given. One test would present descriptions of various types of air cleaners to be identified as to precise type. Another type would present pictures or diagrams of different types for similar identification.

Dusty Climate Air Cleaner

Activity: Practice tests are very simple to devise in this area. The teacher can simply ask the students to identify and describe the type to be used in dusty conditions.

Intake Manifold

Activity: The teacher can explain these functions to students, using a diagram to show the route taken by the vapor. The proximity of the manifold to the combustion chamber enables use of heat to further vaporization. This can be pointed out through use of the diagram.

Activity: The students can then be asked to name and describe the two important functions of the intake manifold. To discriminate between important and unimportant functions, the students should write three unimportant, irrelevant, or coincidental features of the intake manifold (e.g., "the intake manifold holds up the carburetor"). A student probably needs to have a thorough knowledge of the true functions of the intake manifold before he can invent untrue or irrelevant functions. That is the basis of the activity.

Activity: The teacher might give the students practice viewing pictures and/or diagrams of the various types of manifolds. This will familiarize them with the varying manifold designs, plus other specific details such as the heat-control valve. It is also possible to show pictures of exhaust manifolds, explaining their functions. This will contrast the two types of manifolds, giving the students a better understanding of this aspect of the fuel system.

The Main Systems of the Carburetor

Activity: With a diagram and/or a cutaway model, the teacher can carefully introduce the general configuration of the system, locating each part.

Activity: Using a diagram or model, the teacher can demonstrate the actual working of the float and needle valve.

Activity: As a quiz, the students can write descriptions of all parts and their functions. If many of the students cannot write proper descriptions, the teacher should review the various parts and their functions.

Activity: Another type of activity is an oral review. The teacher points to various students and asks them to name a part, or give a description of a part without its name. The student can then call on another student to supply either a description of the part mentioned, or if the first student gave a description, tell what part he was describing. If done fairly rapidly, this can increase the speed of recognition of the various items.

Concentric Float Bowl

Activity: One of the more recent developments in carburetor design is the concentric type float bowl. Therefore, students can be given plenty of exposure to diagrams and descriptions of both eccentric and concentric types. A practice exercise can require the students to write a short paragraph describing the advantages of a concentric design.

Activity: For a homework assignment, students can be asked to formulate one accurate and two inaccurate descriptions of float system function. The next day in class, each student (or as many as possible) reads his three descriptions aloud after which the others indicate which is correct and why. Any questions or misunderstandings concerning this system can be isolated in this way.

Idle and Low Speed System

Activity: The teacher can present to the students various examples of particular specifications for idle adjusting screw settings for several brands of carburetors. The students should memorize these specifications in order to be able to work with the major brands of carburetor.

Activity: The teacher can give his class pairs of statements regarding a certain part, or the system as a whole. One of the statements should be more correct, or express a more widely applicable quality of the specific item being considered.

Here are two examples:

1. a. The idle air bleed's job is to carry air.
   b. The idle air bleed's job is to keep the air to fuel ratios correct.

   (In this pair both a and b are substantially correct, but b tells the ultimate aim of the part's function. B therefore would be more accurate, and therefore is the better answer.)

2. a. The idle and low speed system operates when the car is stationary.
   b. The idle and low speed system operates any time the car is traveling under approximately 12 miles per hour.

   (In this second pair, a is correct. "a" merely states that the idle system operates when the car is stationary; it does not say that it always operates then, which would not be the case if the engine was gunned. On the other hand, "b" emphatically states that the idle and low speed system always works under a certain speed. This would be true most of the time, but, of course, a driver could be coasting at 10 miles per hour, put the car in neutral, and gun the motor. In that case the engine would be operating with the main metering system, even though the car was not traveling at high speed. After reading each pair of statements, the teacher can ask the class to write down which statement was better, and why.)

Adjusting Engine Idle

Activity: Various descriptions of the four methods of idle adjustment can be presented, changing one detail slightly so as to invalidate each method. The students should then write down what is wrong with the description. An example would be:

> "Idle can be adjusted by setting the idle adjustment screw at the point which yields the lowest vacuum reading on a vacuum gauge." If the students have learned why they should have, they will know that it should be the highest vacuum.

Main Fuel Supply System

Activity: Diagrams and/or cutaway models can be used to familiarize the students with each part. The working of the system as a whole must be understood by the student. The teacher can ask various students to quickly describe the several parts, and later the system as a whole.

Activity: The teacher can present three or four descriptions of individual parts, or the system as a whole, one or two of which would be wrong. The students must then identify the incorrect aspects of the descriptions. An example might be:

a. Fuel flows from the fuel bowl into the main well.
b. The main air bleed feeds into the fuel bowl.

"a" is correct, while "b" is not. Students should be able to isolate the flaw in "b".

Activity: The teacher can obtain specific data concerning metering jet aperture (and how it is related to amount of fuel flow) and discharge tube design. If possible, it may be helpful to make a chart showing this information. Once that is done, the teacher can introduce these facts and ask the class to write a detailed description of them as a homework assignment. To test the students' knowledge of metering jet aperture size and discharge tube design, the teacher can present a list of various specifications and diagrams. The students must then identify which are actual specifications for metering jet apertures, and also, which diagrams show actual discharge tube designs.

Power System

Activity: Students can be shown a good diagram of each type of power system design accompanied by appropriate explanations of the working principles of both. To test the students' knowledge of power system design and function, the teacher can ask questions dealing with this subject. Examples:

a. Describe a step-up rod.
b. When does the power system function?
c. What type of power activates the power valve?

Activity: The teacher can give his students practice in identifying correct and incorrect descriptions of this system's function. Here is a sample statement, which is incorrect, "The power system provides the main supply of air/fuel vapor for the engine."

Activity: The teacher can provide the students with detailed information about each type of power valve design, plus a chance to see appropriate diagrams. Sample test question: "What is the location of the diaphragm in the self-contained unit set-up?"

Accelerator Pump

Activity: The operation of the power system can be confused with that of the accelerator pump system. Therefore, the teacher may want to help the students understand the difference. To help the students differentiate between the two, the teacher may read statements about each system. The students must then identify to which system the statements refer. Sample:

a. Delivers an extra amount of fuel to the venturi through the main discharge nozzle.
b. Is controlled by a linkage to the accelerator pedal.

In this pair "a" refers to the power system while "b" refers to the accelerator pump.

Diaphragm and Plunger Types

Activity: In the same way students can be taught the difference between the diaphragm and plunger types. Both are actuated by a linkage, and are alike in general operation. The students should get plenty of practice in identifying diagrams and/or descriptions of both types.

Accelerator Pump Structure

Activity: To better acquaint the students with the structure of the accelerator pump, the teacher can obtain two or three different types of carburetors, dissemble them, and let the students get a first hand look at how each works. Another plan is to allow the students themselves to take the carburetor apart. The teacher should call close attention to the spring and how it acts on the plunger.

Accelerator Pump Adjustment

Activity: The methods of adjusting the stroke of the accelerator pump is an important aspect. A way to illustrate the two methods is to use a pair of carburetors, one of which has an actuating arm with several adjustment holes, and the other of which requires bending of the pump linkage rod. In this way, the students can see the difference between the two methods. Students can practice making the adjustments themselves, if the teacher desires it.

Choke System

Activity: The choke and its several parts are very important to engine performance. The teacher can approach the subject by introducing both manual and automatic chokes. Both perform the same function, but are different enough in design that they may be considered separately.

Activity: One of the points which can be made is that the choke's function is dependent upon changes in temperature (which is how the automatic choke is activated). The teacher can write several different temperatures on the board (80°, 65°, 35°, etc.) and then ask the class to write down whether the choke is open or closed at that temperature, assuming that the car has been started. A variant of this is to ask the students to write whether the air/fuel mixture would need to be richer than normal, or normal at the various temperatures.

Activity: The teacher can take the students to see a car with manual choke and let them see how the linkage works. Then the class can see several different kinds of automatic chokes. The teacher can point out how each is different, with special attention to the workings of the thermostat.

Choke Unloader

Activity: After the teacher has explained the function of the unloader, he can compose various descriptions of choke unloader function, some of which are completely accurate and some of which are completely inaccurate in some way. Example:

a. The choke unloader is activated by vacuum pressure.
b. The choke unloader controls the flow of fuel into the fuel bowl.

(Both of these are false. The students should label each statement as either accurate or inaccurate and should be able to state what is wrong with the inaccurate statements.)

Activity: The choke unloader can be shown rather easily without taking a carburetor apart. The teacher can show how the tang sets off the process, and which parts are involved. The students should learn the precise sequence and be able to describe it in writing.

Idle Vapor Vent

Activity: The students can be given experience in identifying which of several descriptions refers to the idle vapor vent. Some of the descriptions can be completely accurate while others should contain some false statements. Example:

"The idle vapor vent is adjusted by a needle valve." (False.)
"The idle vapor vent prevents fuel from 'boiling' out discharge nozzle in unduly large quantities." (True.)

Activity: The students can be given detailed descriptions of both the idle vapor vent and the thermostatically controlled compensator valve. If possible the students should see diagrams of the two. Then the teacher can ask the students to write a paragraph illustrating the differences between these two parts.

Activity: The student can be asked to identify which part would be used to correct the following conditions:

a. Flooding when engine will not start.
b. Engine straining under a heavy load.
c. Pressure build-up in a fuel bowl.

(This may help the students to identify descriptions of the idle vapor vent. If many students give incorrect identifications, a review of the idle vapor vent, choke unloader, etc. is needed.)

Anti-stall Dashpot

Activity: The teacher can display examples of various types of dashpots indicating to the student the working principle of each. The students can actually disassemble them and examine the parts carefully if time permits. This should increase their knowledge of the dashpot. The teacher can also ask the students questions about the dashpot to check what they have learned. Example: "What does the throttle valve have to push against?" The teacher can also ask the students to learn the exact type of dashpot used on several types of carburetors.

Multiple Barrel Carburetors

Activity: The teacher can give the students practice in identifying the respective parts and functions of the primary and secondary sides of the multiple (4) barrel carburetors by devising various alternative descriptions. Some of the descriptions can be entirely correct while others should contain some inaccuracy. Example: "The secondary section of a four barrel carburetor has its own air horn." (False.) "The primary side of the four barrel carburetor performs the idle and low speed functions." (True.)

Activity: Various statements, each incorrect, but supposedly describing the advantages of multiple barrel carburetors can be devised by the teacher. These can be presented to the students who must identify whether or not they are wrong, and if so, why. Example: "Multiple barrel carburetors provide greater heat for vaporization." (False, number of barrels does not affect carburetor temperature.)

Troubleshooting

Activity: The teacher can point out each part or system that can cause the different malfunctions. One way to familiarize the students with the causes and possible cures of each malfunction is to provide them with a change to identify the important areas on either a cutaway model, a diagram, or both.

Activity: Students can be urged to learn which parts are critical to which malfunctions, etc. For a short quiz, the teacher can ask the class to list the causes and cures of one or two different malfunctions. Or, as a variation, the causes and/or cures can be given after which the students would write the appropriate malfunctions.

Sample questions for practice test might be:

- a. Name two possible causes of hard starting.
- b. What malfunction, or malfunctions can be caused by
  - 1) improperly adjusted throttle stop screw,
  - 2) improperly adjusted fuel level.
- c. What malfunctions could be corrected by these operations?
  - 1) perform all idle adjustments,
  - 2) clean main jets

Activity: After the students know the causes and cure of the various malfunctions the students can disassemble real carburetors to replace parts, set adjustments (e.g., idle screw) etc. By actually working with the carburetor the students can get to know the different aspects of troubleshooting much more quickly.

Activity: A combustion analyzer may also be used to troubleshoot and to test the idle speed system, main and power systems and the accelerator pump system. This can be demonstrated to the students.

APPENDIX B

PRE-TEST, CARBURETION

2

CARBURETION PRE-TEST JUNE, 1966

1. Choose the statement that best defines the term "carburetion."
   a. Carburetion refers to the mixing of air and gasoline in various ratios.
   b. Carburetion is the job done by the carburetor, that is, delivering fuel to the cylinders.
   c. Carburetion is the process of creating a usable ratio of air to gasoline, about 15 to 1.
   d. Carburetion is essentially a chemical reaction of fuel and air facilitated by a narrow tube called the venturi.

2. Select the alternative that includes only valid steps in fuel line installation procedure (metal line):
   a. Use two wrenches. Replace the line in the same position as the previous line was in. Do not bend the line.
   b. Use two wrenches. Bend the line only when necessary to install it in a new position. Be sure to use only flare fittings.
   c. Use a wrench the exact size of the line. Run a pressure test on the line when it is installed. Make sure any breaks in the line due to installation are patched at once.

3. Choose the correct definition of the step-up rod as found in a power system.
   a. A piston which is vacuum actuated.
   b. A rod of various diameters that controls fuel flow for a richer mixture under power.
   c. Delivers air into the discharge nozzle so that the mixture becomes cleaner.
   d. Controls fuel flow to the idling system.

4. Choose the statement that best describes accelerator pump function.
   a. When the car is under a heavy load, it must have more fuel. The accelerator pump provides a more abundant supply of the fuel/air mixture.
   b. The accelerator pump increases the fuel/air mixture during acceleration.
   c. A sudden vacuum, such as when the car is accelerating, causes the accelerator pump to inject more gasoline into the venturi.
   d. When the car is accelerating, the accelerator pump squirts an additional amount of fuel into the venturi.
   e. A special linkage from the accelerator pedal causes the accelerator pump to decrease the air flow by evacuating air from the venturi.

5. Barney's car ran perfectly when he bought it. Now, however, the car's top speed is about 15 mph slower than earlier. Which alternative contains the only possible causes of Barney's dilemma?
   a. Low fuel pump volume, power valve stuck closed, undersized main jets.
   b. Improper valve, obstructed main jets, blocked air bleed.

c. Low fuel pump volume, power valve stuck closed, faulty choke operation.
d. Sticking choke plate, oversized main jet, clogged power system fuel passage to main well.

6. Choose the alternative that accurately explains the processes of atomization and vaporization in the carburetor.
    a. Fuel is atomized, that is, highly heated, in the venturi. It is then vaporized in the firing chamber.
    b. Fuel and air mix together in the carburetor to form a combustible mixture. Vaporization and atomization can both be used to refer to this process.
    c. Fuel is combined with air to form a mixture of gasoline globules and air; that is, atomization. When it gets to the firing chamber it has been to gas, or vapor, that is vaporization.
    d. Fuel is combined into the firing chamber, where it is heated and changed to a more highly integrated mixture, which is atomization.

7. Choose the alternative that best explains the action of the venturi.
    a. The venturi increases gas mileage by making the air/fuel mixture leaner than normal.
    b. The venturi prevents excess air from flowing into the intake manifold by narrowing, and thereby restricting the passage.
    c. The venturi is so shaped that a vacuum is created at the narrow point, causing air to flow through the carburetor at a faster rate.
    d. The venturi's main function is to allow a large quantity of air to enter the carburetor, which is accomplished by the venturi's cylindrical shape. There are no obstructions to air flow as a result.

8. Choose the alternative that best explains the role of heat in the function of the carburetor.
    a. Heat creates a vacuum, which is important in causing air to flow through the carburetor, and also performs mechanical functions (e.g. moving the piston in the power valve assembly).
    b. Heat helps vaporize the gasoline as it enters the intake manifold.
    c. Heat, which is very intense in the venturi due to its shape, helps atomize, and then vaporize the gasoline in the air stream.

Which of the following operations could help correct hard starting? If the operation would help, mark a, if not mark b.

9. Tighten intake manifold.
10. Adjust fuel level.
11. Complete carburetor boil out.

Which of the following operations could help correct rough idle and stalling? If the operation would help, mark a, if not mark b.

12. Replace leaking exhaust gaskets.
13. Repair choke linkage.
14. Adjust choke thermostat.

Which of the following operations could help correct faulty acceleration? If the operation would help, mark a, if not mark b.

15. Adjust accelerator linkage.
16. Adjust throttle stop screw.
17. Clean or replace pump discharge check ball.

18. Both the power valve and the accelerator pump tend to decrease mileage. However, this is not true of both under all circumstances. Which of the following describes a situation in which only one of the two parts is decreasing mileage.
    a. A car is traveling at 30 mph and then begins to climb a steep hill. To help the car up the hill, the driver puts the accelerator all the way to the floor.
    b. A car is at a stop light, and the light changes to green. The driver steps down hard on the accelerator pedal.
    c. A car is pulling a trailer down a hil at 55 mph. The car reaches the bottom of the hill and immediately starts up the next one. The driver senses that his car has slowed down, even though he has not changed the position of the pedal. To help the car up the new hill, he steps down on the pedal until it reaches the floor.
    d. A car is driving at 15 mph. behind a very slow truck. The driver passes the truck, pressing the pedal to the floor as he does so.

19. Select the alternative that is of the most importance when considering the intake manifold:
    a. The intake manifold is part of the fuel system.
    b. The intake manifold is part of the exhaust system.
    c. The intake manifold is responsible for the delivery of a fuel vapor to the engine.
    d. The intake manifold's function is primarily facilitated by heat.
    e. None of the above.

20. Read the following description of main fuel supply system operation, and then choose the alternative that is most appropriate to it.

    The main fuel supply system, as its name implies, is responsible for the supply of the bulk of the vapor used by the engine. When the car is idling, or moving at very low speeds, the main system is inoperative. When the car's speed reaches about 15 or 20 miles per hour (or when the accelerator is depressed and the engine "raced"), the vacuum in the intake manifold draws fuel from the fuel bowl by way of the main well, discharge tube, and discharge nozzle. The fuel and air mixture, which has been partly atomized, enters the barrel and is drawn downward into the intake manifold, where the process of vaporization really begins. The main system continues to supply vapor to the engine in this way until the car reaches about 70 mph. At this point, the power system takes over.

a. This description is correct.
b. The main system operates as soon as the car moves.
c. The fuel mixture is already vaporized when it enters the barrel; this is facilitated by the main air bleed.
d. The power system supplements, but doesn't fully replace the main fuel supply system at very high speeds.
e. The main system is also replaced, during rapid acceleration, by the accelerator pump. The main system operates when a steady speed is maintained, in other words.

APPENDIX C

POST-TEST, CARBURETION

CARBURETION TEST, JUNE 1966

1. Choose the statement that best defines the term "carburetion."
    - a. Carburetion refers to the mixing of air and gasoline in various ratios.
    - b. Carburetion is the job done by the carburetor, that is, delivering fuel to the cylinders.
    - c. Carburetion is the process of creating a usable ratio of air to gasoline, about 15 to 1.
    - d. Carburetion is essentially a chemical reaction of fuel and air facilitated by a narrow tube called the venturi.

2. Select the alternative that includes only valid steps in fuel line installation procedure (metal line):
    - a. Use two wrenches. Replace the line in the same position as the previous line was in. Do not bend the line.
    - b. Use two wrenches. Bend the line only when necessary to install it in a new position. Be sure to use only flare fittings.
    - c. Use a wrench the exact size of the line. Run a pressure test on the line when it is installed. Make sure any breaks in the line due to installation are patched at once.

3. From the several choices listed below, choose the one which describes the best way to measure fuel pump delivery.
    - a. With engine running, disconnect the fuel line at the carburetor and install a pressure gauge. The gauge should read 7-11 pounds, for most carburetors.
    - b. Disconnect the fuel line at the fuel bowl. The bowl should drain in 15 seconds.
    - c. With engine running and fuel line disconnected at the carburetor, catch the fuel in a container. Delivery should be about one pint in 30 seconds, at a specific rpm.
    - d. Disconnect the fuel line at the carburetor and check the flow of fuel from the outlet passage. A steady unbroken stream indicates proper fuel delivery.
    - e. The only way to check proper fuel pump operation is to dismantle the pump and inspect the part.

In questions 4, 5, and 6 the main types of air cleaners are listed, while the second lettered list contains their definitions. Match each name with its correct definition.

4. Oil bath type.
5. Oil wetted mash type.
6. Dry type.

a. The air is cleaned by a filter which has been moistened with oil.
b. The air first passes through a wet, and then dry filter.
c. A pool of oil collects dirt as the air is blown through it.
d. An unwetted filter element is used to trap particles.
e. The air passes over a pool of oil, and then goes through a filter element, wetting that element with globules of oil.

7. Select the alternative that best describes the function of the intake manifold.
   a. The intake manifold delivers the fuel/air mixture to the cylinders.
   b. The burned gases are taken into the exhaust system by the intake manifold.
   c. The intake manifold serves to heat, and hence to vaporize the fuel/air mixture on its way to the firing chamber.
   d. a and c are true.
   e. a and b are true.

8. Choose the alternative that best describes the function of the float.
   a. The float controls the amount of fuel immediately available for use.
   b. The float seals off the vent tube that leads to the venturi.
   c. The float controls the needle valve.
   d. a, b, and c are all correct.
   e. a and c are correct.

9. Choose the alternative that most accurately describes the float needle valve.
   a. Is controlled by the motion of the float.
   b. Meters gasoline into the float bowl.
   c. Can become clogged with tiny particles of dirt.
   d. a and c are appropriate.
   e. a, b, and c are all appropriate.

10. Which of the following alternatives does not describe one of the four ways to adjust engine idle.
    a. Engine idle may be adjusted by setting the idle adjustment needle valve to factory specifications.
    b. Engine idle may be adjusted by attaching an adjustment gauge to the idle discharge port and turning the needle valve accordingly.
    c. Engine idle may be adjusted by ear; that is, turning the needle valve to the point where the engine idle sounds the smoothest.
    d. Engine idle may be adjusted by setting the idle screw at a point where you get the highest vacuum reading on a vacuum gauge, with a steady needle.
    e. Engine idle may be adjusted by using a tachometer, setting the idle at the point where the highest rpm reading is.

11. Choose the best description of the main metering jet.
    a. Delivers fuel to the venturi due to a sudden vacuum.
    b. Allows a specially prescribed amount of fuel to pass from the fuel bowl to the main well.
    c. Extends into the venturi.
    d. Fuel enters this part from the fuel bowl.

12. Choose the correct definition of the step-up rod as found in a power system.
    a. A piston which is vacuum actuated.
    b. A rod of various diameters that controls fuel flow for a richer mixture under power.
    c. Delivers air to the discharge nozzle in order to make the mixture leaner.
    d. Controls fuel flow to the idling system.

13. Read the following description of power system function, and then choose the alternative that is most appropriate to it.

The power system goes into operation when the engine is under a heavier than normal strain. To increase the power of the engine, a valve opens and allows a greater than normal amount of the fuel/air mixture to be ejected into the venturi. As a consequence, the car picks up speed, whereupon the valve closes until the next emergency.
  a. This is an accurate description of the power system function.
  b. This is correct except that the car does not necessarily pick up speed.
  c. The action of the valve is that of making the fuel/air mixture richer, rather than just increasing its volume.
  d. A cylinder, not a valve, is the activating part in the system.
  e. b and d are both applicable.

14. Choose the statement that best describes accelerator pump function.
  a. When the car is under a heavy load, it must have more fuel. The accelerator pump provides a more abundant supply of the fuel/air mixture.
  b. The accelerator pump increases the fuel/air mixture during acceleration.
  c. A sudden vacuum, such as when the car is accelerating, causes the accelerator pump to inject more gasoline into the venturi.
  d. When the car is accelerating, the accelerator pump squirts an additional amount of fuel into the venturi.
  e. A special linkage from the accelerator pedal causes the accelerator pump to decrease the air flow by evacuating air from the venturi.

15. Choose the best definition for the choke shaft.
  a. The part upon which the choke valve rotates.
  b. The part upon which the breather valve rests.
  c. A narrow part which extends into the thermostat housing.
  d. The part which causes the choke valve to open or close.
  e. None of the above.

16. Choose the best definition for the choke valve.
  a. A round object that constricts the passage just below the venturi.
  b. Closes off the air passage above the venturi.
  c. A valve which, when closed stops the flow of fuel into the main well.
  d. A valve which cuts off the flow of fuel/air mixture from the discharge nozzle and is linked to the accelerator pedal.
  e. None of the above.

17. Barney's car ran perfectly when he bought it. Now however, the car's top speed is about 15 mph slower than earlier. Which alternative contains only possible causes of Barney's dilemma?
  a. Low fuel pump volume, power valve stuck closed, undersized main jets.
  b. Improper valve, obstructed main jets, blocked air bleed.

c. Low fuel pump volume, power valve stuck closed, faulty choke operation.
d. Sticking choke plate, oversized main jet, clogged power system, fuel passage to main well.

18. Choose the best explanation of why air flows through the carburetor.
a. Air flows through the carburetor because of the rapid movement of the pistons.
b. Air flows through the carburetor because the venturi is narrowed in the middle which facilitates the flow.
c. Air flows through the carburetor because the air cleaner has a sucking action that draws in the air.
d. Air flows through the carburetor because the air pressure is lower in the combustion chamber than in the outside air.

19. Choose the alternative that accurately explains the processes of atomization and vaporization in the carburetor.
a. Fuel is atomized, that is, highly heated, in the venturi. It is then vaporized in the firing chamber.
b. Fuel and air mix together in the carburetor to form a combustible mixture. Vaporization and atomization can both be used to refer to this process.
c. Fuel is combined with air to form a mixture of gasoline globules and air; that is atomization. When it gets to the firing chamber, it has been changed to gas, or vapor, that is vaporization.

d. Fuel is fed into the firing chamber, where it is heated and changed to a more highly integrated mixture, which is atomization.

20. Choose the alternative that best explains the action of the venturi.
a. The venturi increases gas mileage by making the air/fuel mixture leaner than normal.
b. The venturi prevents excess air from flowing into the intake manifold by narrowing, and thereby restricting the passage.
c. The venturi is so shaped that a vacuum is created at the narrow point, causing air to flow through the carburetor at a faster rate.
d. The venturi's main function is to allow a large quantity of air to enter the carburetor, which is accomplished by the venturi's cylindrical shape. There are no obstructions to air flow as a result.

21. Choose the alternative that best explains the role of heat in the function of the carburetor.
a. Heat creates a vacuum, which is important in causing air to flow through the carburetor, and also performs mechanical functions (e.g., moving the piston in the power valve assembly).
b. Heat helps vaporize the gasoline as it enters the intake manifold.
c. Heat, which is very intense in the venturi due to its shape, helps atomize, and then vaporize the gasoline in the air stream.
d. Heat is responsible for the maintenance of proper fuel level by means of a thermostatic control.

Which of the following operations could help correct hard starting? If the operation would help, mark a, if not mark b.

22. Adjust choke thermostat.
23. Clean choke passages, blowing out with compressed air.
24. Repair or replace defective choke plate or linkage.
25. Tighten fuel line to fuel pump.
26. Replace defective main metering jet.
27. Adjust defective dashpot.
28. Adjust stroke of accelerator pump.
29. Tighten intake manifold.
30. Adjust fuel level.
31. Complete carburetor boil out.

Which of the following operations could help correct stalling when the accelerator is suddenly released. If the operation would help, mark a, if not mark b.

32. Clean discharge nozzle.
33. Replace dashpot.
34. Replace heat tube.
35. Adjust accelerator pedal linkage.
36. Replace idle tubes.
37. Tighten idle tube fittings.
38. Adjust throttle stop screw.
39. Clean fuel filter.
40. Replace filter screen in fuel pump.

Which of the following operations could help correct rough idle and stalling? If the operation would help, mark a, if not mark b.

41. Replace leaking exhaust gaskets.
42. Adjust fuel level.
43. Adjust throttle stop screw.
44. Adjust or replace dashpot.
45. Repair choke linkage.
46. Adjust choke thermostat.
47. Check secondary systems.

Which of the operations could help correct faulty acceleration? If the operation would help, mark a, if not mark b.

48. Adjust pump strokes.
49. Adjust accelerator linkage.
50. Adjust throttle stop screw.
51. Clean or replace pump discharge check ball.
52. Clean idle adjustment needle valve.
53. Clean float bowl needle valve.
54. Correct sticking throttle valve.

In the following questions read the specific condition stated and then choose the alternative that best describes or lists the result or results of that condition.

55. Oversize metering jet:
    a. Hard starting will result.
    b. Mileage will be impaired.
    c. More gasoline will pass into the main well than is normal.
    d. A richer than normal mixture will be created.
    e. All but a.

56. Very low fuel pump volume:
    a. Engine lacks power when hot only.
    b. Engine overheats.
    c. Surging at most speeds.
    d. Surging at low speeds only.

57. Which of the following statements describes the change that should be made in the carburetor when driving at very high altitudes?
    a. A gas ratio of 8/1 is used.
    b. A smaller size metering jet is used.
    c. A larger size metering jet is used.
    d. The choke valve is set to allow less air into the venturi.
    e. No change needs to be made.

58. The air pressure at a certain elevation is 12 1/4 p.s.i. Which of these alternatives would be appropriate to such a situation?
    a. This is sea level, and would be a normal driving condition.
    b. This air pressure is that of sea level, but air pressure has nothing to do with engine performance.
    c. A larger than normal metering jet would be used here.
    d. A smaller than normal size main metering jet would be used.
    e. By itself, air pressure tells us little about driving conditions.

59. Choose the statement which best characterizes the role of heat in carburetion.
    a. Heat controls certain parts.
    b. Heat facilitates a chemical change.
    c. Heat controls engine idle speed.
    d. All but 1.
    e. All but 3.

60. If it were not for the venturi restriction,
    a. air flow would increase.
    b. atomization would be increased.
    c. air flow would decrease.
    d. the carburetor could not function at all.
    e. all but 1.

61. Complete this sentence: Vacuum action in the carburetor
    a. is probably the most important cause of the carburetor's operation.
    b. is mainly an auxiliary feature.
    c. is mainly concerned with controlling idle speed.
    d. is important in a chemical reaction.
    e. cannot be understood without understanding the principle of fuel level.

62. A student of carburetion would be interested in fuel pump delivery measurement because
   a. it helps familiarize him with the fuel pump and with various measurement instruments.
   b. fuel supply is vital to carburetor operation.
   c. it helps tell him whether the fuel line from the tank is doing its job.
   d. he will probably have to service fuel pumps as well as carburetors when he gets a job.
   e. it is somewhat easier than servicing the carburetor, and hence is a good place to start working with actual parts.

63. Which of the following words does not refer to an action or object which could affect fuel level?
   a. Puncture
   b. Dirt particle
   c. Restriction
   d. Nozzle
   e. All of the above could affect fuel level.

64. Which of the following is not true of the main air bleed?
   a. It prevents undue pressure build-up.
   b. It improves mileage.
   c. It prevents "raw" fuel from being drawn into the barrel.
   d. It aids atomization.
   e. All of the above are true.

65. Both the power valve and the accelerator pump tend to decrease mileage. However, this is not true of both under all circumstances. Which of the following describes a situation in which only one of the two parts is decreasing mileage.
   a. A car is traveling at 30 m.p.h. and then begins to climb a steep hill. To help the car up the hill, the driver puts the accelerator all the way to the floor.
   b. A car is at a stop light, and the light changes to green. The driver steps down hard on the accelerator pedal.
   c. A car is pulling a trailer down a hill at 55 m.p.h. The car reaches the bottom of the hill and immediately starts up the next one. The driver senses that his car has slowed down, even though he has not changed the position of the pedal. To help the car up the new hill, he steps down on the pedal until it reaches the floor.
   d. A car is driving at 15 m.p.h. behind a very slow truck. The driver passes the truck, pressing the pedal to the floor as he does so.

Match the following terms with the systems to which they belong:

66. Check ball
   a. Accelerator pump
   b. Idle system
   c. Main fuel system
   d. Choke

67. Pump return spring
    a. Choke unloader
    b. Accelerator pump
    c. Power system
    d. Float system

68. Metering rod (step-up rod)
    a. Accelerator pump
    b. Idle system
    c. Main fuel system
    d. Dashpot assembly

69. Which of the following malfunctions is most likely to result from a float needle valve stuck open?
    a. Poor acceleration
    b. Flooding
    c. Too lean a fuel mixture
    d. a and b are true
    e. a, b and c are true.

70. What is the most important reason for checking the manifold heat valve often?
    a. Driving conditions change from one area to another.
    b. If it isn't functioning correctly, fuel consumption will increase.
    c. Undue wear and tear on the manifold will result.
    d. The idle will be too fast or too slow, depending on how the heat valve is adjusted.
    e. b and d are correct.

71. Select the alternative that is of the most importance when considering the intake manifold.
    a. The intake manifold is part of the fuel system.
    b. The intake manifold is part of the exhaust system.
    c. The intake manifold is responsible for the delivery of a fuel vapor to the engine.
    d. The intake manifold's function is primarily facilitated by heat.
    e. None of the above.

72. Choose the statement that best describes accelerator pump function:
    a. When the car speeds up, the accelerator pump controls the flow of fuel.
    b. When more fuel is needed to operate the engine, the accelerator pump increases the amount in the main well.
    c. The accelerator pump is controlled by a spring attached to a bi-metal coil.
    d. None of the above adequately describes the accelerator pump.

73. Which statement best describes the main advantage of multiple barrel carburetors?
    a. They provide better mileage.
    b. They give an extra burst of fuel at high speeds.

c. Only part of the multiple barrel carburetor is operating most of the time, thereby saving on wear and tear.
d. They provide for better mixing of fuel and air due to more venturi space.
e. They provide for better fuel distribution to the several cylinders.

74. Read the description of accelerator pump linkage adjustment procedure shown below, then select the alternative which best fits the description.

To adjust any type accelerator pump linkage, it is necessary to bend the linkage rod. The distance from the top of the carburetor float bowl cover to a prescribed point on the pump plunger shaft, as indicated by specifications, is measured and the rod bent to obtain the correct distance.
a. This is a correct description.
b. The pump actuating arm, not the linkage rod, is the part that is bent.
c. Before the measurement can be made, the idle adjusting screw must be screwed all the way in.
d. For carburetors whose pump actuating arms have more than one hold for the linkage, a simple change can be made to another hold.
e. b and c are correct.

75. Read the following descriptions of choke function, and then select the one which best describes said function.
a. To help the engine run more efficiently, the choke plate chokes off the top of the venturi passage during warm weather.
b. To insure quick starts in the morning, the choke system chokes off the idle air bleeds to increase the gas ratio delivered to the engine.
c. To insure better performance when a richer than normal air/fuel mixture is needed, the choke system reduces the amount of air sucked into the venturi.
d. To insure quick starts in the morning, the choke system is activated by a thermostatic control. This means that the choke responds to changes in temperature (such as in the morning, when it is cold).
e. None of the above alternatives accurately describes the function of the choke system.

76. Choose the description that best describes the function of the choke unloader.
a. The choke unloader closes the circuit to the thermostatic control, thereby causing the choke to function.
b. The choke unloader only works when the temperature is quite low, and there is danger that the engine will not start.
c. The choke unloader opens the choke valve to prevent the engine from flooding.
d. The choke unloader only operates when a richer mixture is needed; that is why it opens the choke valve, which causes a richer fuel mixture.
e. c and d are both correct.

77. Which one of the following three alternatives contains only true statements about the anti-stall dashpot?
    a. The dashpot is connected to the choke unloader since they perform related functions. Like an overdrive unit, the dashpot may be operated or not, at the driver's will. Both diaphragm and plunger types are made.
    b. The dashpot operates automatically when the driver takes his foot off the accelerator pedal hurriedly. The diaphragm types prevent the throttle valve from closing too rapidly by forcing the valve to push against a spring or quantity of air, which slows down the closing of the throttle valve.
    c. The dashpot prevents stalling due to sudden release of the accelerator pedal. The plunger type makes use of a plunger that expels gasoline from a cylinder. The dashpot is connected with the accelerator pedal by means of a linkage.

78. Choose the alternative that best describes the idle discharge ports:
    a. The idle discharge ports are located just below the throttle valve.
    b. The idle discharge ports are located just above and below the throttle valve.
    c. The idle discharge ports squirt gasoline into the idle fuel passages.
    d. The idle discharge ports bleed air into the venturi.
    e. The idle discharge ports are controlled by the action of the float.

79. Choose the alternative that most accurately describes the function of the idle air bleed:
    a. The idle air bleed operates as an extension of the main air bleed.
    b. The idle air bleed is necessary to keep the air/fuel mixture in proper balance in case the main air bleeds are clogged or blocked.
    c. The idle air bleed prevents the fuel/air mixture from becoming too rich during low speed operations.
    d. The idle air bleed draws unwanted pressure from the float bowl during idling.
    e. The main air bleed and the idle air bleed draw air from the outside through the same aperture.

80. Choose the alternative that best describes the idle adjusting needle valve:
    a. The idle adjusting needle valve works in much the same way as the needle valve in the float system.
    b. The specific adjustment of the idle needle valve affects the performance of the carburetor.
    c. By turning the idle adjusting screw, the amount of air/fuel mixture discharged from the idle port can be varied.
    d. By turning the idle adjusting screw, the ratio of air to gasoline discharged from the idle port can be varied.
    e. The idle adjusting screw is mounted horizontally, below the throttle valve, and should be adjusted to factory specifications.

81. Choose the alternative that best describes the idle fuel passages:
    a. The idle fuel passages feed fuel into the discharge nozzle.
    b. One of the idle fuel passages leads to the discharge nozzle, while the other leads to the idle discharge ports after mixing with the idle air bleed.
    c. The idle fuel passages lead first to the idle air bleed, and then to the idle discharge ports.
    d. The idle fuel passages are auxiliary, and operate only in the event of a malfunction in the main fuel passages.
    e. The idle fuel passages lead from the fuel bowl directly to the idle discharge ports.

82. Choose the answer which lists the type of fuel filter that cannot be cleaned and used again.
    a. Gas tank oilite filter.
    b. Ceramic fuel pump filter.
    c. Carburetor inlet filter.
    d. Flexlline filter (between fuel pump and carburetor).

83. Complete this sentence with one of the following alternatives.

    A mechanic has forgotten to replace the fuel filters when reassembling a fuel system which he had taken apart to check: therefore..................
    a. the performance of the carburetor will not be greatly affected because no harmful particles enter the fuel tank.
    b. the accelerator pump will not function properly, though the carburetor should be largely unaffected otherwise.
    c. the precisely measured amounts of fuel which pass through the passages in the carburetor should still be able to meter the correct amounts.
    d. too little an amount of fuel will enter the carburetor.

84. Read this description of idle-low speed operation and then select the alternative that is most appropriate to it.

    The idle system enables the engine to function even though the car is not moving; otherwise, the engine would die every time a car stopped at a red light. To do this, the idle system makes use of separate fuel and air passages. When the throttle is closed, the vacuum in the intake manifold draws fuel and air through these separate passages. As the throttle is opened, additional openings are exposed, thereby allowing more fuel to enter the main barrel.

85. Read the following description of main fuel supply system operation, and then choose the alternative that is most appropriate to it.

    The main fuel supply system, as its name implies, is responsible for the supply of the bulk of the vapor used by the engine. When the car is idling, or moving at very low speeds, the main system is inoperative. When the car's speed reaches about 15 or 20 miles per hour (or when the accelerator is depressed and the engine "raced," the vacuum in the intake manifold draws fuel from the fuel bowl by way of the main well, discharge tube, and discharge nozzle. The fuel and air mixture, which has been partly atomized, enters the barrel and is drawn downward into the intake manifold, where the process of vaporization really begins. The main system continues to supply vapor to the engine in this way until the car reaches about 70 mph. At that point, the power system takes over.

a. This description is correct.
b. The main system operates as soon as the car moves.
c. The fuel mixture is already vaporized when it enters the barrel; this is facilitated by the main air bleed.
d. The power system supplements, but doesn't fully replace the main fuel supply system at the very high speeds.
e. The main system operates when a steady speed is maintained, in other words.

Below is listed a series of malfunctions. After each appear four alternatives. Each alternative lists several letters which refer to parts shown on your diagram. Choose the alternative which lists only parts which would normally be investigated when trying to determine the cause or causes of the particular malfunction. (The correct alternative contains only parts pertinent to the malfunction, though not necessarily all pertinent parts.)

86. Hard Starting
a. M, Q, A
b. A, B
c. A, Q
d. C, I, B

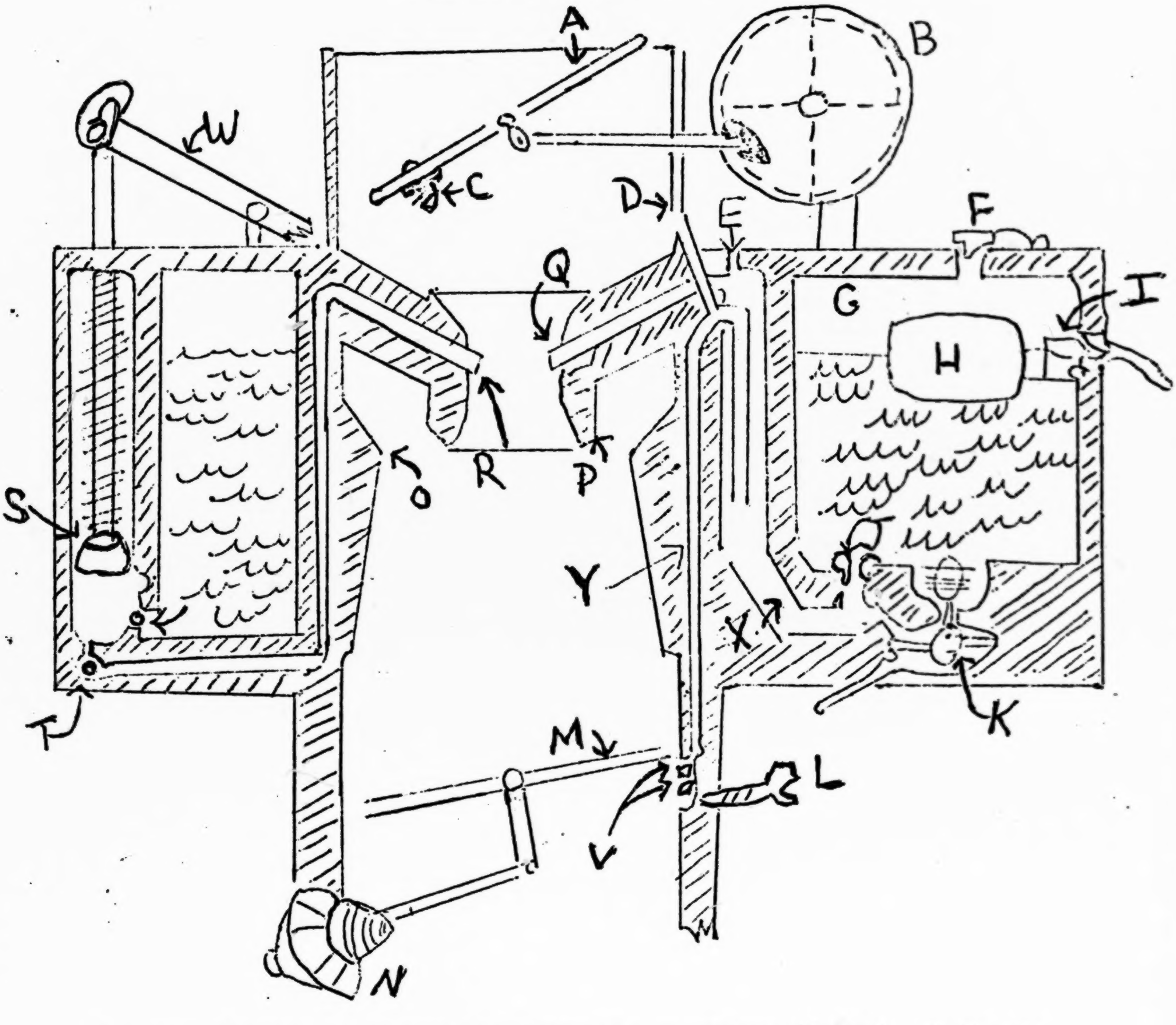
87. Stalling due to sudden release of accelerator pedal.
a. S, E, N
b. D, N, S
c. S, L, I
d. E, N, D

88. Rough idle and stalling
a. D, I, L
b. H, I, E
c. H, E, J
d. I, H, Q

89. through 99. - on the following page.

100. Faulty Acceleration
a. T, S, R
b. R, M, J
c. S, H, M
d. T, R, M

POST TEST, CARBURETION



Use your diagram to answer the following questions (89-99). Write the letter which identifies each part in the space provided

89. Venturi ______
90. Float bowl ______
91. Float ______
92. Float bowl needle valve ______
93. Discharge nozzle ______

94. Throttle valve ______
95. Choke valve ______
96. Choke breather valve ______
97. Choke thermostat ______
98. Idle vapor vent ______
99. Idle adjustment screw ______

NAME ______________________

APPENDIX D

STUDENT QUESTIONNAIRE, CARBURETION

STUDENT QUESTIONNAIRE
CARBURETION UNIT

Directions: Please help us to improve this unit by answering the following questions. Your suggestions and general reactions will only be used for this purpose so be as frank as you can. Thank you.

1. Name ________________________ Instructor's Name ____________________

2. How many previous courses have you had in auto mechanics? __________

3. What is your approximate grade point average in the auto mechanics courses you have completed? (A = 4.0) _____.

4. What was your overall grade point average in high school? (A = 4.0) _____.

5. After you finish school do you plan to enter the auto mechanics field? (check one) ___1, definitely yes, ___2. probably, ___3. uncertain, ___4. probably not, ___5. definitely not.

6. How would you rate your interest in the general field of auto mechanics? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low.

7. Before the unit how would you rate your interest in the specific topic of carburetion? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low.

8. After this unit how would you rate your interest in the specific topic of carburetion? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low.

9. With respect to the topics covered in this unit, I was: ___1. extremely interested, ___2, interested, ___3. neutral, ___4. bored, ___5. extremely bored.

10. If more material of this type were available, I would: ___1. definitely study it on my own, ___2. probably study it on my own, ___3. not know whether to study it, ___4. probably not study it on my own, ___5. definitely not study it on my own.

11. In general, I think the field of auto mechanics is: ___1. exciting, ___2. interesting, ___3. of average interest, ___4. uninteresting, ___5. dull.

12. The practical value of the information in the unit was: ___1. very great, ___2. above average, ___3. average, ___4. below average, ___5. very little.

13. If a friend of mine were studying auto mechanics, I would urge him to: ___1. definitely study this topic, ___2. probably study this topic, ___3. be indifferent about this topic, ___4. probably avoid this topic, ___5. definitely avoid this topic.

14. I felt the post-test (completed today) was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

15. I felt the pre-test (completed earlier) was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

16. Most of the material treated during the unit was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

17. Please make any suggestions on back of this sheet which you feel might assist in improving the unit, tests, etc.

APPENDIX E

INSTRUCTIONAL UNIT, POWER SUPPLIES

INSTRUCTIONAL UNIT, POWER SUPPLIES

Experimental Version III

January, 1967

INTRODUCTION

You will be participating in an experimental trial of a new teaching unit based on the topic of power supplies. We are attempting to see how effectively teachers can accomplish the instructional objectives presented in this unit. To help us perform this trial, we ask you to observe a few guidelines. First, read the content outline. This will give you an overall idea of what the unit covers. Next, read the list of specific objectives very carefully. This is important, because they will describe precisely what your students must learn. Always remember to refer to the specific objectives when you are in doubt as to what you are supposed to teach.

The exact procedure of our experiment is this. First, a member of our staff will visit your class before you begin the unit. He will administer a short test, using test items based explicitly on the objectives you have been given. The results of this pre-test will indicate how much your students know about power supplies before they actually start the unit. Then you will teach the unit, taking not more than ten hours. Of course, you may not need that much time, but this will be the maximum time allowed. After the unit has been taught, we will once more send a representative to your class. Again he will administer a test, based exclusively on the objectives for the unit. This final test will be somewhat longer, in order to obtain a more thorough measurement of the attainment of the class. After that, we will welcome any comments, suggestions or criticisms you may wish to make with regard to the unit, the objectives, or any other aspect of this project.

Other than the time limitation of ten instructional hours, there is only one rule which we ask you to follow. Teach to the objectives given in this unit. We recognize that you may have different preferences regarding objectives for a unit on power supplies. However, for purposes of the experiment please try your best to accomplish the objectives given here. After the unit has been completed we shall seek your judgment regarding the value of the various objectives. But for this trial, please plan your teaching in order to achieve the student behaviors outlined in this unit. Therefore, you will want to adopt a plan that will most efficiently teach those skills, abilities, etc., to your students.

We recognize that some things can be taught which are not covered in our objectives. Goals involving values and attitudes are very important, and cannot be overlooked. However, these kinds of teaching goals are very difficult to observe, especially in the short time we have. Therefore, we have purposely limited our objectives to only those which call for a readily observed behaviors stated in our objectives that we are interested in and testing for. As a teacher, you know that instilling in your students an appreciation for proper use of tools, for instance, is a worthy teaching goal. But it lies outside the scope of this experiment. We are not suggesting that you forget about such goals. We simply ask you to emphasize the skills, etc., that are outlined in the objectives given in this unit.

INSTRUCTIONAL UNIT, POWER SUPPLIES

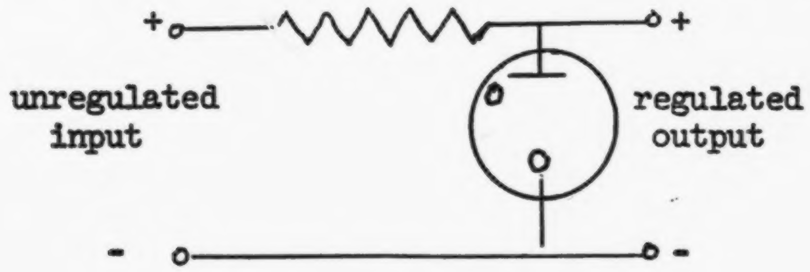
Voltage Regulator Circuits

There are two basic types of voltage regulator circuits: shunts and series. Zener diodes and glow-discharge tubes are commonly used as the active elements in shunt regulator circuits, whereas the grid-controlled tube is often used in some form of series regulator circuit.

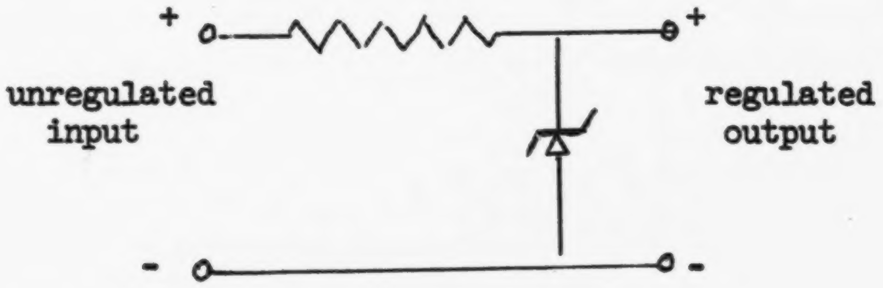
The figure below shows the voltage regulator circuits which will be used in this unit. The series regulator circuit employing the grid-controlled tube is a simple example of a series regulator, and is not covered in detail in this unit.

1. Shunt (parallel) Voltage Regulator Circuits

   a) Voltage Regulator using a glow-discharge tube:

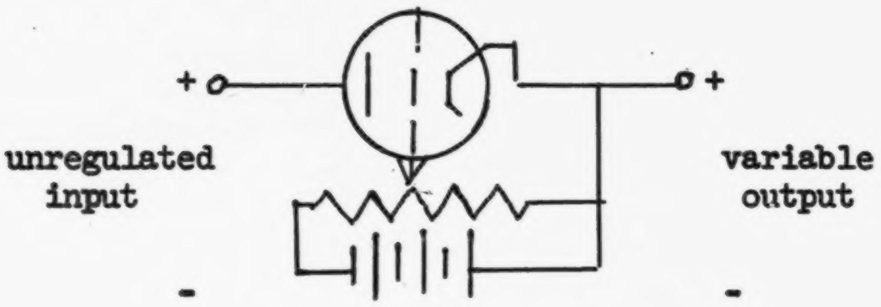

+
unregulated input
-
+
regulated output
-

   b) Voltage Regulator using a zener diode:


+
unregulated input
-
+
regulated output
-

2. Series Voltage Regulator Circuit

   c) Voltage Regulator using a grid-controlled vacuum tube:


+
unregulated input
-
+
variable output
-

CONTENT OUTLINE

Following is a general outline of the different topics included in this unit on power supplies. The organization is not arbitrary. However, neither is it the only way to approach the subject. It is not designed as a basis for your teaching plan, although you are perfectly free to use it as such. Rather, it is to familiarize you with the areas covered by the unit's objectives. The headings used here will be the key to the resource unit which follows the list of objectives, enabling you to orient yourself when using the reference materials.

A. Basic Power Supplies

1. Transformer
2. Rectifier
3. Filter
4. Voltage Regulator
5. Voltage Doubler

B. Half-Wave Rectifiers

1. Diode Vacuum Tube
2. Selenium Rectifier
3. Diode Ratings

C. Full-Wave Rectifiers

1. Dual Diode Vacuum Tube
2. Semiconductor
3. Bridge Circuit

D. Filter Circuits

1. Choke-input
2. Capacitive-input
3. Bleeder Resistor
4. Filter Component Ratings

E. Voltage Regulator Circuits

1. Glow-discharge Tube
2. Grid-controlled Tube
3. Zener Diode
4. Series Resistor

F. Power Supply Requirements

1. Load Capability
2. Component Selection

UNIT OBJECTIVES

In this section the instructional objectives for the unit are presented. As stated earlier, please use any instructional technique you wish to achieve them, but design your teaching to accomplish as many of these objectives as you can in the time allowed to you. The content outline headings will be repeated here, each one followed by the objectives appropriate to it. (Information regarding particular parts of the power supply in relation to these objectives may be found in the resource unit.)

A. Basic Power Supplies

1. Given definitions of the following terms, the student should match correctly the terms with the definitions.
    a. Transformer
    b. Rectifier
    c. Filter
    d. Voltage regulator

2. Given a series of schematic representations of the following components, the students will correctly match each component with its schematic drawing.
    a. Transformer
    b. Selenium rectifier
    c. Diode vacuum tube
    d. Dual diode vacuum tube
    e. Inductor
    f. Capacitor
    g. Resistor
    h. Glow-discharge tube
    i. Potentiometer
    j. Grid-controlled tube
    k. Zener diode
    l. Battery

3. Given a schematic diagram of a typical power supply, the student should correctly identify the:
    a. Transformer circuit
    b. Rectifier circuit
    c. Filter circuit
    d. Voltage regulator circuit

4. Given the primary, high voltage secondary, and low voltage secondary winding of a transformer and a list of colors, the student will correctly match EIA color code for each winding.

5. Given a schematic diagram of a voltage doubler and a peak-to-peak AC input, the student should correctly determine the DC voltage output.

B. Half-Wave Rectifiers

6. The student should select the definition giving the best description of the following terms:
   a. Diode vacuum tube
   b. Selenium rectifier

7. Given five different wave forms the student should select each form, if any, that represents the unfiltered output of a half-wave rectifier. Note that the output may be either positive or negative, depending on how the diode is connected.

8. Given a schematic diagram of a rectifier circuit (with either a vacuum tube or selenium diode, singly or in series) with diode ratings and application of requirements, the student should select the ratings, if any, that are exceeded for each diode.

C. Full-Wave Rectifiers

9. The student should select the definition giving the best description of the following terms:
   a. Dual diode vacuum tube
   b. Semiconductor
   c. Bridge circuit

10. Given five different wave forms the student should select each form, if any, that represents the unfiltered output of a full-wave rectifier. Note that the output may be either positive or negative.

11. Given a list of advantages and disadvantages characteristic of conventional full-wave rectifiers and bridge rectifiers, the student should correctly identify the advantage/disadvantage with the appropriate rectifier.

12. Given two bridge circuit schematic diagrams, the student will correctly trace the electron current flow.

13. Given a schematic diagram of a full-wave rectifier circuit (conventional or bridge) with diode ratings, the student should select the ratings, if any, that are exceeded for the application.

D. Filter Circuits

14. Given a list of the following types of filters and a list of filter characteristics, the student should correctly match each filter with its characteristics:
   a. Capacitive-input
   b. Choke-input

15. Given five different wave forms the student should select each form, if any, that represents the voltage wave form at the output of a half-wave rectifier with a simple capacitor filter in parallel with the load.

16. The student should select the correct alternative describing the usual effect of each of the following filters on current flow:
    a. Capacitive-input
    b. Choke-input

17. The student should identify the alternatives that describe the purposes of a bleeder resistor.

18. Given a schematic diagram of a filter circuit with specifications and the load requirements, the student should select the ratings, if any, that are exceeded for each component.

E. Voltage Regulator Circuits

19. Given a shunt regulator component with DC operating voltage and current range, and a power supply with a specified load, the student will be able to correctly calculate the effect of utilizing the regulator component in series or parallel in the regulator circuit.

20. Given a list of the characteristics of voltage regulator circuits, the student will correctly match the characteristics with a glow-discharge tube, a grid-controlled tube, a zener diode, or more than one of these regulators.

21. Given a schematic diagram of a shunt voltage regulator circuit with component specifications and the load requirements, the student should select the alternative identifying the series resistor as either too large, too small, or meeting the requirements.

F. Power Supply Requirements

22. Given a schematic diagram of a power supply with component ratings and application requirements, the student will evaluate each component and select the ratings, if any, that are exceeded.

23. Given a list of available components, their ratings, and the requirements for a power supply, the student should draw a schematic diagram of a power supply using the given components that would meet the requirements.

RESOURCE UNIT

You have now read the content outline and a list of specific objectives. What you must teach is contained therein.

This resource unit is divided into two parts. The first contains characteristics (to include definitions, advantages/disadvantages, and purposes for components and circuits of power supplies), schematic diagrams, and basic assumptions. Its purpose is to familiarize you with the language and assumptions we use, and the boundaries put on each content area. It is, of course, not designed to teach you about power supplies.

The second part contains possible learning activities. You may use some, all, or none of them as you see fit. How you teach the unit is up to you. We offer these activities as possibilities only.

The second part of the resource unit, as the first, follows the headings of the content outline. All possible learning activities are denoted by the word "activity."

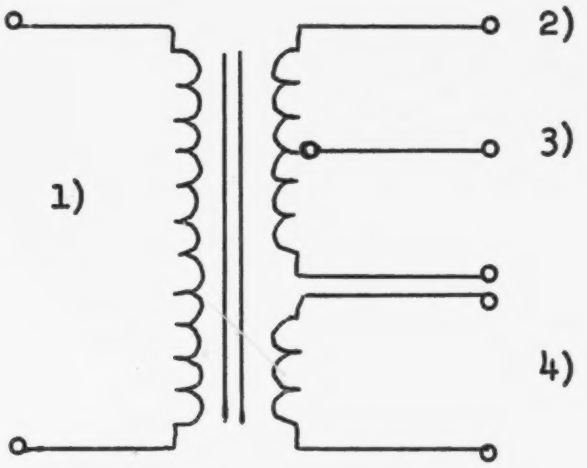
PART I: CHARACTERISTICS, SCHEMATIC DIAGRAMS, AND BASIC ASSUMPTIONS

Basic Power Supplies

Transformer

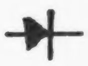
A device using the principle of mutual inductance having a primary winding connected to a voltage source and one or more secondary windings connected to a load(s).

The EIA color code for transformers is as follows: 1) the primary winding is black, 2) the high voltage secondary winding is red, 3) the high voltage secondary center tap is red-yellow, and 4) the rectifier filament winding is yellow.

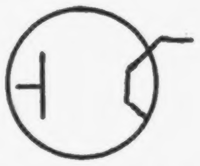


Rectifier

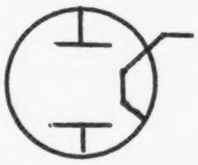
A circuit used to change AC voltage input to a DC voltage output. The schematics below are rectifier components.



Selenium rectifier
or semiconductor



Diode vacuum tube

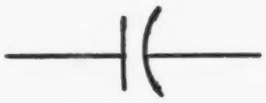


Dual diode vacuum tube

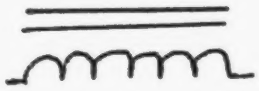
Rectifier circuits include the diodes above arranged in circuits for half-wave or full-wave rectification.

Filter

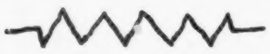
A circuit used to eliminate undesired voltage variations through the use of capacitance and inductance. The schematics below are filter components.



Capacitor



Inductor

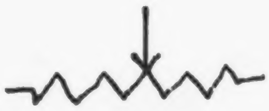


Resistor

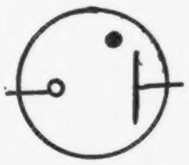
Filter circuits may be constructed of only an inductor or a capacitor (with or without a resistor) or of inductors and capacitors connected in series and/or parallel. Often a bleeder resistor is used in the circuit.

Voltage Regulator

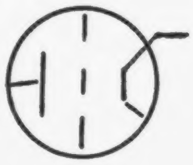
A circuit utilizing component parts to maintain a given output voltage. The schematics below are regulator components.



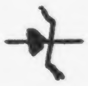
Potentiometer



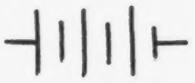
Glow-discharge tube



Grid-controlled tube
(triode)



Zener diode

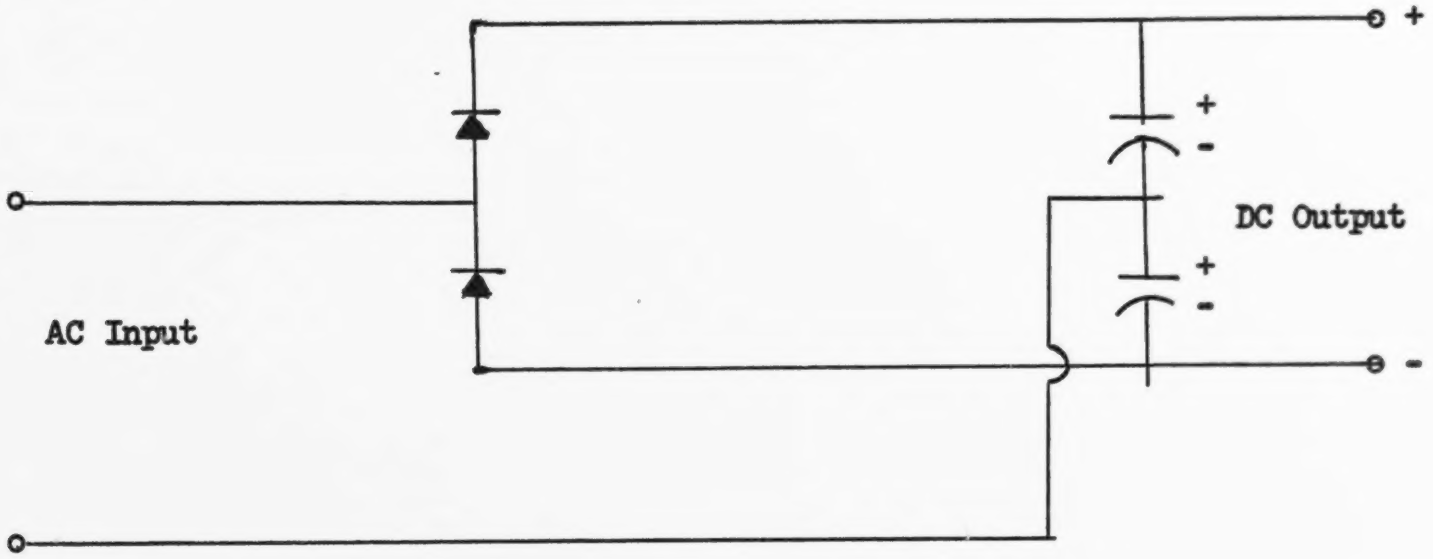


Battery

Regulator circuits use the components diagramed in different combinations to produce given output voltage(s) under varying load conditions.

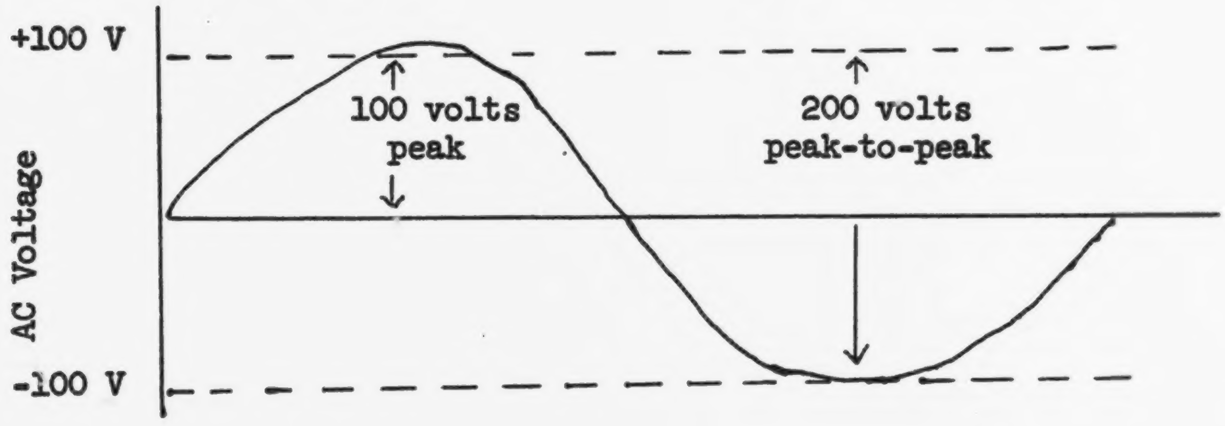
Voltage Doubler

The schematic diagram shown below is that of a simple voltage doubler. In this circuit the DC output voltage is approximately twice the peak value of the AC input under no load conditions.


+
+
-
DC Output
+
-
AC Input
-

Typical Schematic Diagram Of A
Voltage Doubler Circuit

There are several ways to specify an AC voltage. Two methods will be used for this unit: peak and peak-to-peak. No RMS values will be used.


+100 V
100 volts
peak
200 volts
peak-to-peak
AC Voltage
-100 V

Half-Wave Rectifiers

Diode vacuum tube

A tube with a heated cathode giving up electrons to a plate only when the plate is positively charged resulting in a DC current flow.

Selenium rectifier

A series of iron disks coated on one side with selenium having a high resistance to current flow in one direction and a low resistance in the opposite direction.

Diode ratings

a) For this unit all diodes will be assumed to be ideal. That is, the resistance to current flow in the forward direction is assumed to be zero (causing the forward voltage drop to be zero), and the resistance to current flow in the reverse direction is assumed to be infinite.

b) The Peak Inverse Voltage (PIV) is the maximum voltage appearing across the diode during the time of non-conduction. If the peak inverse voltage appearing across a diode is greater than its PIV rating, the diode will fail. When two or more diodes are placed in series the PIV rating for the group is the sum of their individual PIV ratings.

c) The Maximum Current rating of a diode is the maximum (peak) current which can flow during the time of conduction without causing failure of the diode.

The following are considered characteristics of a capacitive-input filter:

a) draws a large surge current from the rectifier when the supply is turned on

b) the output closely approximates the peak voltage of the input if the load is light

c) results in poor voltage regulation with heavy loads

d) draws high peak currents from the rectifier

Bleeder resistor

The bleeder resistor is considered to have two purposes. The first is to provide a minimum load for a power supply to prevent excess voltage when the load is removed. The second is to bleed off current from the filter capacitors when the power supply is turned off, thus proving a safety factor.

Filter component ratings

a) capacitor: the working voltage (DCWV) of a capacitor is the voltage that it will withstand continuously. It will be assumed that if the peak voltage appearing across a capacitor exceeds its working voltage the capacitor will fail.

b) inductor (choke): chokes usually have a rated current since their physical size limits the amount of internal power dissipation, which is equal to the product of the internal winding resistance and the square of the load current through the choke. Since the internal winding resistance is constant, the internal power dissipation is dependent solely upon the load current through the choke. It will be assumed that if the current through the choke exceeds its rated current the choke will fail.

c) bleeder resistor: it will be assumed that if the power being dissipated in the bleeder resistor exceeds its power rating the resistor will fail.

Full-Wave Rectifiers

Dual diode vacuum tube

A vacuum tube with two separately connected plates and a single cathode.

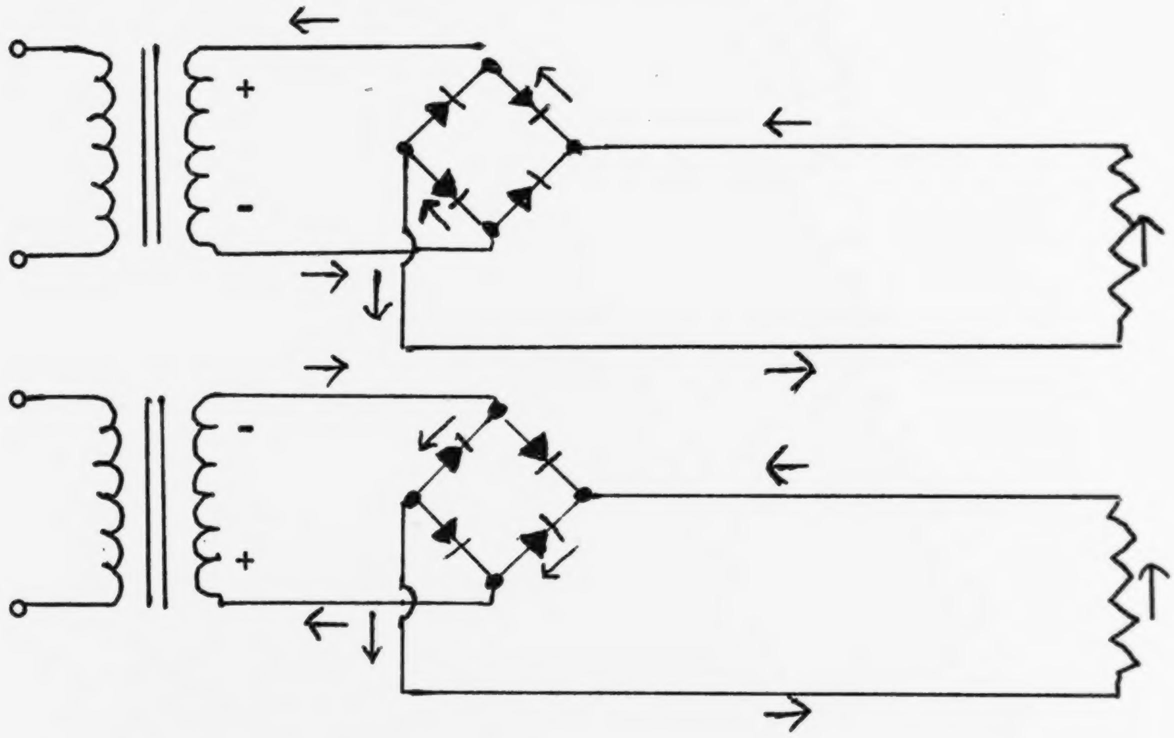
Semiconductor

A class of elements with characteristics falling between conductors and insulators.

Bridge circuit

a) a circuit with four diodes arranged such that AC current flows through two diodes at a time producing a pulsating DC output.

b) the electron flow in a bridge circuit for the first and second half of an AC cycle is shown below:



The following are considered to be advantages of the bridge rectifier as compared with the conventional full-wave rectifier:

a) requires a lower PIV diode rating for a given output voltage

b) does not require a center-tapped transformer

c) delivers twice the output voltage for a given transformer

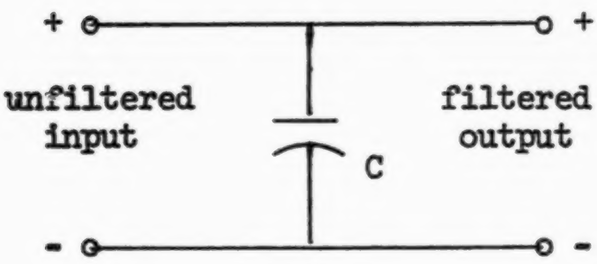
The following is considered to be the advantage of the conventional full-wave rectifier as compared with the bridge rectifier: requires only two diodes.

Filter Circuits

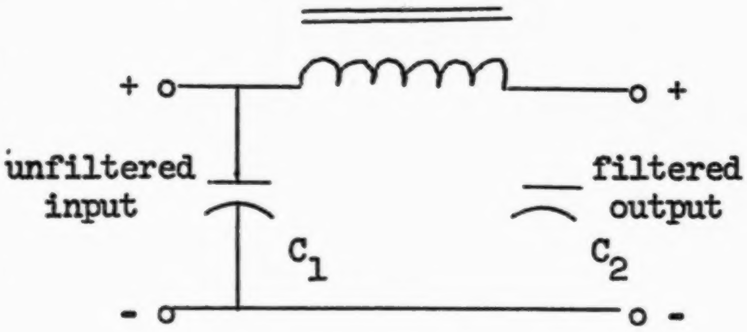
Filter circuits may be divided into two categories: choke-input and capacitor-input. The schematic diagrams of three common filter circuits are shown in the figure below.

1. Capacitor-input filters:

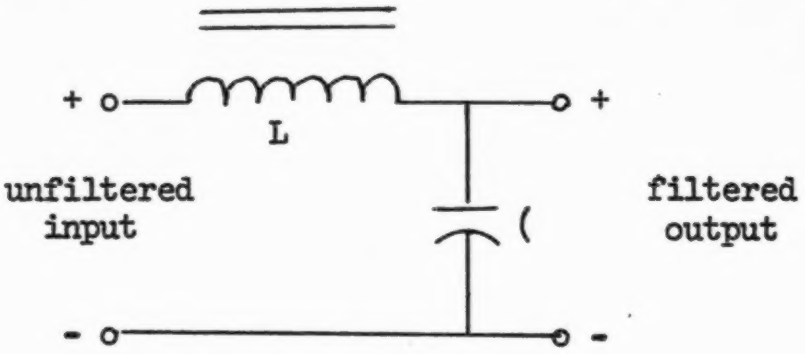
a) simple capacitor filter


+
+
unfiltered input
filtered output
C
-
-

b) Pi-section filter


+
+
unfiltered input
filtered output
C_1
C_2
-
-

2. Choke-input filter


+
+
L
unfiltered input
filtered output
C
-
-

The following are considered characteristics of a choke-input filter:

a) best for filtering heavy loads

b) better utilization of the rectifier than a comparable capacitive-input filter

c) allows a rectifier with a low peak current rating, as the choke makes efficient use of current from the rectifier

d) gives good regulation under moderate to heavy loads

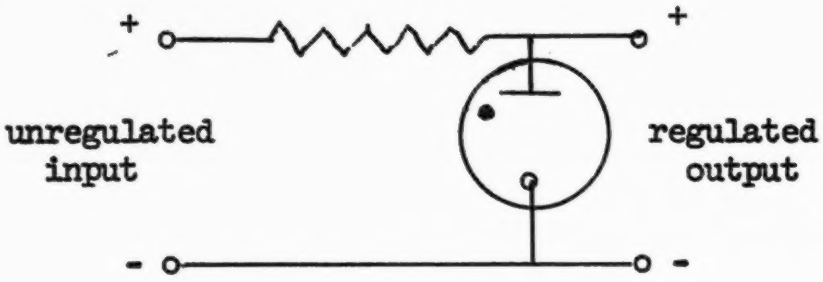
Voltage Regulator Circuits

There are two basic types of voltage regulator circuits: shunts and series. Zener diodes and glow-discharge tubes are commonly used as the active elements in shunt regulator circuits, whereas the grid-controlled tube is often used in some form of series regulator circuit.

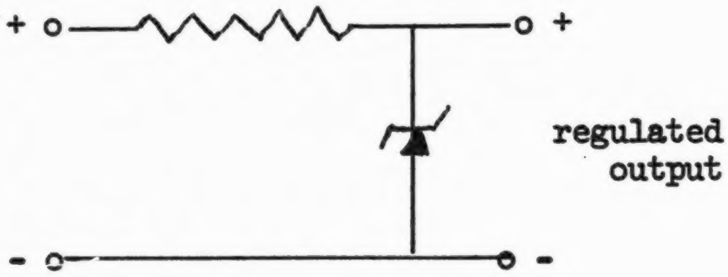
The figure below shows the voltage regulator circuits which will be used in this unit. The series regulator circuit employing the grid-controlled tube is a simple example of a series regulator, and is not covered in detail in this unit.

1. Shunt (parallel) Voltage Regulator Circuits

   a) Voltage Regulator using a glow-discharge tube:

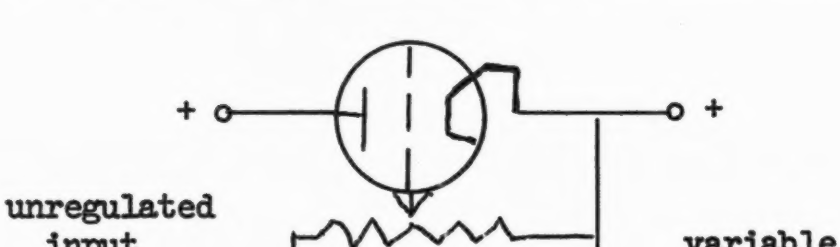

+
+
unregulated input
regulated output
-
-

   b) Voltage Regulator using a zener diode:


+
+
regulated output
-
-

2. Series Voltage Regulator Circuit

   c) Voltage Regulator using a grid-controlled vacuum tube:


+
+
unregulated input
variable output
-
-

Glow-discharge tube

The glow-discharge tube has a rated regulation voltage over a rated current range, which will be assumed to be 5 to 40 milliamps. It will be assumed that as long as the current through the tube is within the specified range, the voltage across the tube will be exactly the rated regulation voltage. If the current through the tube is greater than 40 ma. it will be assumed that the tube will fail. If the current through the tube is less than 5 ma. it will be assumed that the tube has no effect upon the circuit.

The following are considered characteristics of a glow-discharge tube:

a) produces a fixed output voltage

b) can be placed in series when greater voltages are required

c) is limited to small currents (5 to 40 ma.)

d) provides a simple method of voltage regulation (shunt)

Grid-controlled tube

Due to the complexity of series regulators in general, the only rating which will be considered for the grid-controlled tube is the current through the tube (plate current). It will be assumed that if the current through the tube exceeds the maximum specified current the tube will fail.

The following are considered characteristics of a grid-controlled tube:

a) capable of handling high voltage at small currents

b) capable of continuous variation of output voltage

Zener diode

The zener diode has a rated regulation voltage over a rated current range, which will be assumed to be from zero to the maximum current specified for each diode. It will be assumed that as long as the current through the diode is within the specified range, the voltage across the diode will be exactly the rated regulation voltage. If the current through the diode is greater than the maximum current specified it will be assumed that the diode will fail.

The following are considered characteristics of a zener diode:

a) capable of handling high voltage and heavy current

b) produces a fixed output voltage

c) can be placed in series when greater voltages are required

d) has the smallest physical size

e) provides a simple method of voltage regulation (shunt)

Series resistor

The value of the series resistor used in shunt regulator circuits must be chosen with care. If it is too small, the current through the zener or glow-discharge tube may exceed its specified maximmm, causing failure of the tube or zener. If it is too large, the current through the zener or glow-discharge tube may fall below its specified minimum, causing the output voltage to drop below its prescribed value.

PART II: POSSIBLE LEARNING ACTIVITIES

Basic Power Supplies

Activity: An activity which would in all probability be quite effective in helping the students learn thorough but concise definitions of the basic components of the power supply system is simple homework. Have each student write out as complete a definition or description as they can for a transformer, rectifier, filter, and voltage regulator. Be certain that the definitions they have written are discussed well in class so that each student is able to see where his work was correct or insufficient.

Activity: Another possible activity to accomplish a complete knowledge of the definitions of the major components of a power supply system is to have the class comment on an incomplete definition of a major component as written on the board by the instructor. They should be asked to add, delete, and reword until the definition fully covers the functions and characteristics of each power supply component as mentioned above.

Activity: The students can be urged to learn which schematic symbols represent various parts of the power supply system. One way to do this would be to lecture the class on the various symbols, showing them drawings of them on the board as you proceed. After the lecture the instructor could have them draw the symbols on a piece of paper as he calls out the component name. The parts to be used would include the transformer, selenium rectifier, diode vacuum tube, dual diode vacuum tube, inductor, capacitor, resistor, glow-discharge tube, potentiometer, grid-controlled tube, zener diode, and battery.

Activity: For further instruction relevant to the mastery of these schematic symbols, the instructor could pass the physical part around the room with a tag connected to it. On the tag should be drawn that part's schematic diagram so that the students would be able to see the correlation between the symbol and the part, and thereby achieve, perhaps, a better contextual base for working with these schematics.

Activity: Since it is important that your students understand the workings of the power supply system as a whole (where the electricity comes from and what happens to it), much time may feasibly be devoted to this portion of the unit. One way to achieve this sort of overall understanding is to show the students a series of diagrams of circuits, proceeding from the more simple to the moderately complex. About each diagram you could have the students write a short paragraph about anything that was special or unique, the appropriateness of the circuit for various jobs, or any mistakes you may have purposely drawn in. When you are through, have them correct their own papers so they can see where they were right and wrong.

Activity: Another activity that might be helpful in this area would be for the instructor to draw up several different power supply schematics, and to show them to the class while at the same time asking individual class members to label the various circuits of the power supply, or the transformer, rectifier, filter, and voltage regulator.

Activity: The EIA color code is commonly used to designate the various windings of a transformer. Therefore, it may be advisable for the students to memorize the different colors and what winding in the transformer they denote. After the students have been given this assignment be certain to quiz them, to be sure that they do not need more work in this area.

Activity: Another activity that could be used to help the students learn this color code would be to, as homework, draw a schematic of a transformer, labeling each winding with its appropriate color. These may be corrected in class, to be certain that not only the students know the color code, but also that they are able to draw a schematic of a transformer.

Activity: As an activity on the voltage doubler the instructor could draw a schematic of a voltage doubler on the board, with a graph of the peak-to-peak AC input next to it. The instructor could then trace the electron flow, explaining how the doubled voltage output is obtained, performing the necessary computations as he proceeds.

Activity: A practical demonstration of the functioning of the voltage doubler would be for the teacher to bring such circuits to class, along with two voltmeters, one AC and one DC. He would then compare input voltage with output voltage in lab conditions. Remember that the AC voltmeter will probably read in RMS volts rather than peak volts, so that the necessary computations should be made.

Half-Wave Rectifiers

Activity: The instructor could lead the class in a discussion of the function and manner in which a diode vacuum tube operates. The conclusions or results of this discussion could then be compared or contrasted with the conclusions of a similar discussion of the selenium rectifier. Be certain that your discussion weighs carefully the advantages and disadvantages of each.

Activity: A simpler activity pertaining to the student's learning of this material would be to have them search out, from relevant literature, definitions or descriptions of a diode vacuum tube and a selenium rectifier. Then have the students read aloud their definitions and the class can correct them until a complete definition is achieved.

Activity: The instructor could, after a short lecture, give an identification quiz on electrical wave forms, and specifically on the unfiltered wave form (positive and negative) at the output of a half-wave rectifier. If the results of the quiz are not satisfactory, more time should probably be devoted to an explanation of wave forms and the function of rectification.

Activity: Another possible activity on this material would be for the instructor to use an oscilloscope to display the input and unfiltered output wave forms of current through a half-wave rectifier.

Activity: An activity that might be helpful in this area would be to put on the board a series of rectifier circuits, including diode ratings, and to then vary the load requirements on each one. Have the pupils determine both when the rating is correct, and what should be done when they are exceeded. This will give the students some good practice in solving this type of problem.

Activity: For a more complete understanding as well as a perhaps greater practical usage of their knowledge, the students could in groups of two or three, work on actual circuits, changing both the diodes and the loads. They could thereby see how different loads effect the diode rating requirements, and the results of exceeding the diode ratings.

Full-Wave Rectifiers

Activity: After a short lecture the teacher could have the different members of the class attempt to define or describe the dual diode vacuum tube, a semiconductor, and a bridge circuit. After this discussion has achieved complete definitions, each student should be required to write it down for future reference.

Activity: Another approach to the mastery of the meaning of these terms would be for the teacher to give the students these definitions in a lecture and then pass out to each student a piece of paper that gives a number of definitions for each term. The student would then be required to select the best alternative for each. If the results of this quiz are less than desirable, more time may be given to this portion of the unit.

Activity: The students could be led in a discussion on the characteristics of the unfiltered output wave forms (positive and negative) of a full-wave rectifier. At this point, the instructor could point out the similarities and differences between the output wave forms of the full-wave and half-wave rectifiers.

Activity: After this discussion, a number of wave forms could be drawn on the board and the students asked to point out which are the wave forms that represent the unfiltered output of a full-wave rectifier.

Activity: The teacher could have the class compare and contrast (including advantages and disadvantages) the conventional full-wave rectifier with the bridge rectifier (assuming a similar transformer to be used in both cases) in an essay. These essays should be read by the students in front of the class, at which time additions or deletions could be made at the suggestion of either the rest of the class or the instructor.

Activity: To further instruct the class as to the advantages and disadvantages characteristic of the usual full-wave rectifier and a bridge rectifier circuit, the teacher could divide the class in half, and have each half first draw up schematically a conventional full-wave rectifier circuit and a bridge rectifier circuit respectively. Then you could have them actually build a circuit utilizing the diagrams they have already designed and then compare and contrast the two circuits in terms of PIV required, materials needed and used, cost, etc.

Activity: The instructor could, on the board, trace out the direction of current flow in a bridge rectifier circuit, for both the positive and negative half-cycles of the input wave form. The students should then be allowed to practice this type of problem on a short quiz, and the results should indicate whether or not more time will be needed here.

Activity: For further instruction in this area, the teacher could deliver a short lecture which would explain what effect the diode has on the direction of current flow in a bridge circuit.

Activity: One way to teach your class how to select proper diode ratings in either a conventional full-wave rectifier or a bridge rectifier, is to have a number of these circuits built up. Then in front of the class you can demonstrate practically what happens when you change diodes (with different ratings), while maintaining a constant load. You can then explain why each diode used failed or was appropriate.

Activity: The instructor could also draw on the board the schematic diagrams of several different full-wave rectifier circuits including a conventional with dual diode vacuum tube or semiconductor, and a bridge circuit. Also, the diode ratings should be listed. He could then explain what requirements each particular circuit type places on the diode ratings, as well as the procedure for calculating whether the ratings will be exceeded.

Filter Circuits

Activity: One way for the students to achieve an understanding of both chokes and capacitors in filter circuits is for the instructor to make up a chart, delineating for several different load requirements what filter circuit is used, and why. The chart should be discussed and notes taken by the students, and the next day a matching quiz could be given them wherein they could be required to match each filter with its characteristics.

Activity: Another approach here would be for the instructor to use an oscilloscope to display the filtering capabilities of both the choke-input filter and the capacitive-input filter at light, medium, and heavy loads.

Activity: After a lecture on this material, the students could be given a short quiz that would require them to draw the wave forms at the output of a half-wave rectifier with a simple capacitor filter in parallel with the load, and the same through a half-wave rectifier and a choke input filter. Also, they should be asked to explain the difference between the two.

Activity: Another approach to this material would be for the instructor to draw a number of wave forms on the board and have the students select those that represent the voltage wave form at the output of a half-wave rectifier with a simple capacitor filter in parallel with the load.

Activity: Given a series of written alternatives describing the effect of choke-input filters and capacitor-input filters on current flow, the teacher could ask the students to label those relating to capacitors A, those relating to chokes B, and those that are irrelevant C. For example:

B. Is especially well suited for heavy loads.
A. Increases current flow from the rectifier.
C. Enables the circuit to function under all conditions without any other form of regulation.

Activity: As a homework assignment the teacher may have the students search out the usual effect on current flow of the capacitive-input filter and the choke input filter. The pupils should write their findings out, and they could be discussed in class the next day.

Activity: The importance of the bleeder resistor could be shown by having the class build a small power supply using a simple capacitor filter without such a resistor, and then note how excess voltage builds up when there is no load. This also demonstrates how electrical energy is stored in the capacitor and how the bleeder resistor dissipates it. This portion of electronic circuits deserves a good deal of class time, as it is crucial to the safety of the students working with power supplies that they understand the function of this resistor.

Activity: The instructor could also draw on the boad several power supply schematics (including bleeder resistors) with component values and specified loads. Having done this the teacher could then perform calculations illustrating the proper procedure for selecting the correct resistance value and voltage rating of the bleeder resistor.

Activity: One of the most important things to teach your students is the ability to determine from a given filter circuit diagram, with specifications, the maximum load requirements that that circuit would meet. Therefore, it would seem wise to give some instruction on this type of computation, and to then hand them a series of diagrams with specifications and have them calculate the maximum load requirements each circuit would meet.

Activity: Another way in which this goal might be attained would be to have your students write out, in essay form, the correct procedure for determining whether or not the ratings have been exceeded in a filter circuit. This would be a useful activity as the students, through the verbalization of this process, may better understand and remember it.

Voltage Regulator Circuits

Activity: In the older regulated circuits and some today, you find the glow-discharge tube. Because they are frequently found, it is important that the students learn how they function as regulators. One way to accomplish this would be to lead a class discussion as to why the tube glows, the effect of current on the tube and vice versa, and what results are obtained by using them in series and parallel in the regulator circuit.

Activity: The instructor could demonstrate the effect of utilizing the regulation circuit in series or parallel in the power supply by showing with a volmeter and an ammeter the different voltages and currents obtainable by changing the configuration of the regulator circuit.

Activity: As there are several possible ways of regulating voltage, it might be a good idea for the class to be familiar with the advantages and disadvantages of each type. Considering the material involved, perhaps the best way to do this would be to lecture the students as to which type of regulator to use (between a gas diode, triode, or a zener diode) under given and varied conditions. Then pass out a series of problems that require the students to calculate and draw a circuit from written description of a circuit and load, with the type of regulator he feels would be best, and then have him write out a rationale for his selection.

Activity: Another approach to this would be for the instructor to hand out in class lists that would give the characteristics of the three different types of voltage regulators considered in this unit, or the zener diode, glow-discharge tube, and the grid-controlled tube. The instructor could then discuss these characteristics with the class and give them a quiz the next day that would require them to match the characteristics given with the respective regulators.

Activity: A good thing for the students to practice for this unit has to do with the determination of a proper series resistor with respect to a shunt voltage regulator circuits with specifications, and to have the students show or explain a given series resistor would have on each circuit.

Activity: The instructor could, in a lecture situation, draw several shunt voltage regulator circuits on the board, giving component specifications and load requirements. He could then show how to perform the requisite calculations to compute the value of a series resistor. At the end of the lecture the teacher could conduct a sort of oral spot quiz by having some students come to the board and perform such calculations on other schematics of shunt voltage regulator circuits.

Power Supply Requirements

Activity: It is definitely important for your students to be able to see when components of the total power supply circuit with specifications and applications fit requirements, and are able to calculate which, if any components are exceeded. A series of problems of this nature might be given to the class as a whole, and the instructor could ask students individually and orally to calculate, or show how to calculate whether any of the rating are exceeded.

Activity: To achieve a practical knowledge of the components of a power supply, the instructor could pass out to the students component specifications supplied by various manufacturers of power supply components. The instructor could discuss these specifications with the class, showing how their study would have practical applications.

Activity: Practice in drawing circuits from component specifications is one skill that might come in handy in future dealings with electronics and power supplies. Have your students draw at least five diagrams of power supply circuits that would meet the requirements set up for each from component specifications.

Activity: For further work in this area, the teacher could have the students build up one of the five power supplies the student had designed in the above learning activity. After he had built it up, he should then be asked to evaluate the performance of the power supply through the use of laboratory equipment.

APPENDIX F

PRE-TEST, POWER SUPPLIES

PRE-TEST, POWER SUPPLIES

Version III, January 1967

1. Select the appropriate definition for the term Voltage Regulator

   a. A circuit used to eliminate undesired voltage variations through the use of capacitance and indurance.

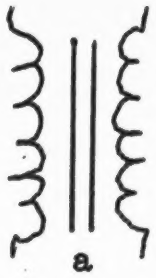
   b. A circuit used to change AC voltage input to a DC voltage output.

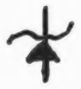
   c. An instrument used to reduce current to a desired value or to produce a specified voltage drop.

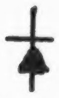
   d. A device using the principle of mutual inductance having a primary winding connected to a voltage source and one or more secondary windings connected to a lead(s).

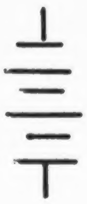
   e. A circuit utilizing component parts to maintain a given output voltage.

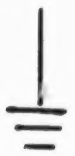
The next two questions (2-3) require the correct matching of the numbered terms with the schematic drawing given above them.


a


b


c

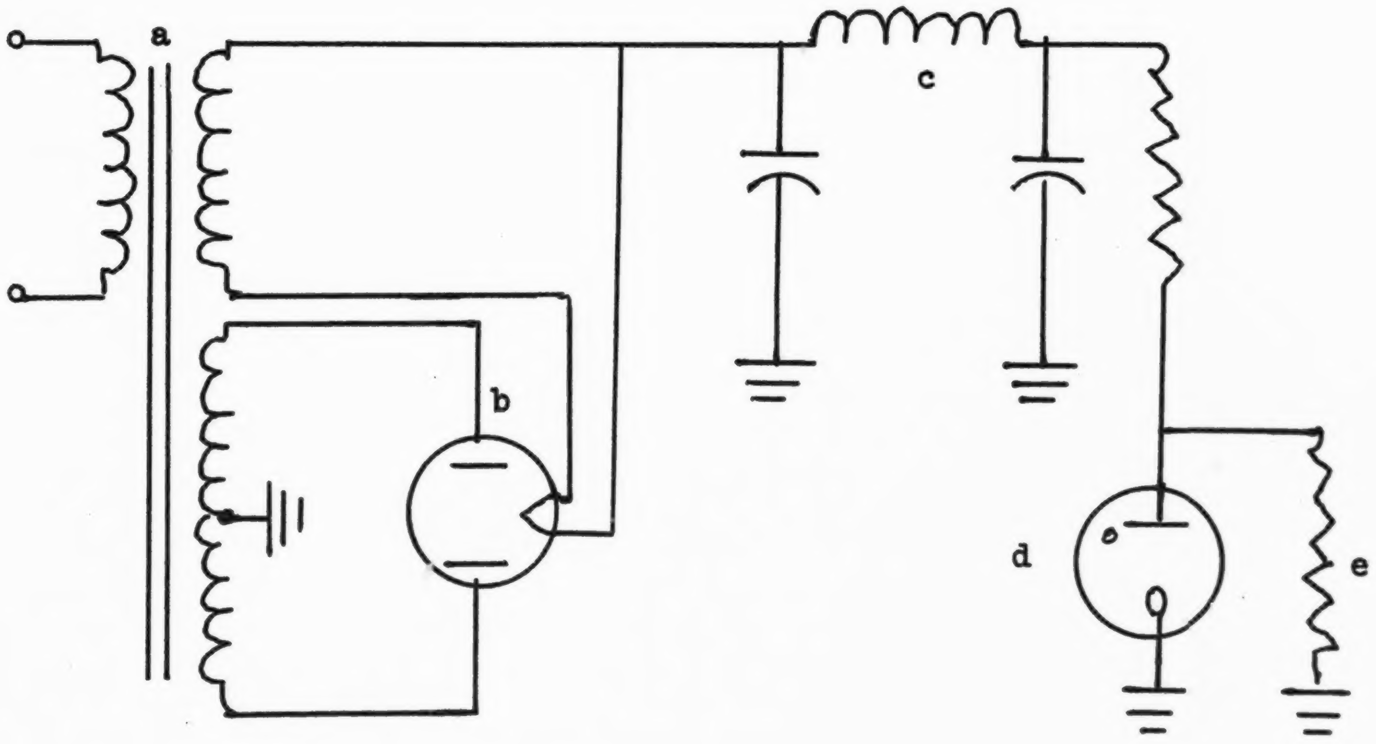

d


e

2. Zener diode

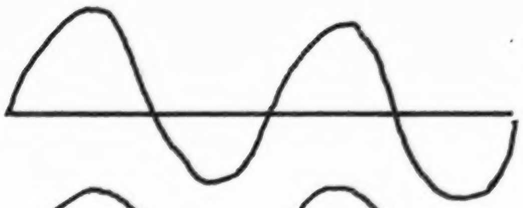
3. Battery

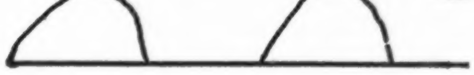
The schematic diagram below is of a typical power supply

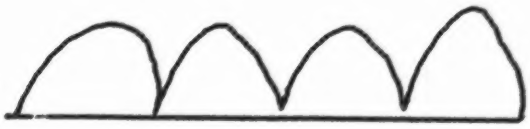


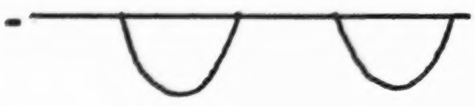
4. The diagram has been divided into five sections. Identify the transformer section.

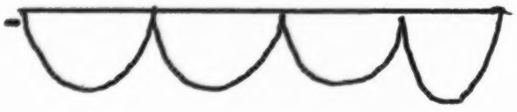
5. Select each of the following wave forms, if any, that represents the unfiltered output of a half-wave rectifier.

a. + -


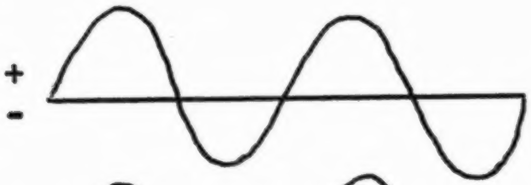
b. + -


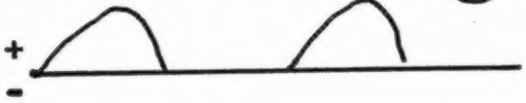
c. + -


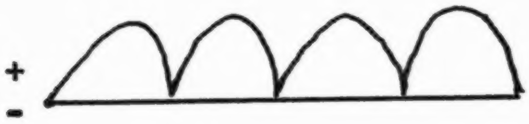
d. + -


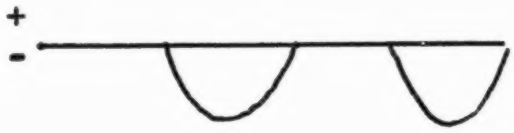
e. + -


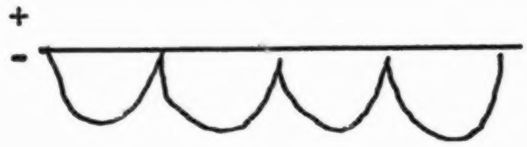
6. Select each of the following wave forms, if any, that represents the unfiltered output of a full-wave rectifier.

a.


b.


c.


d.


e.


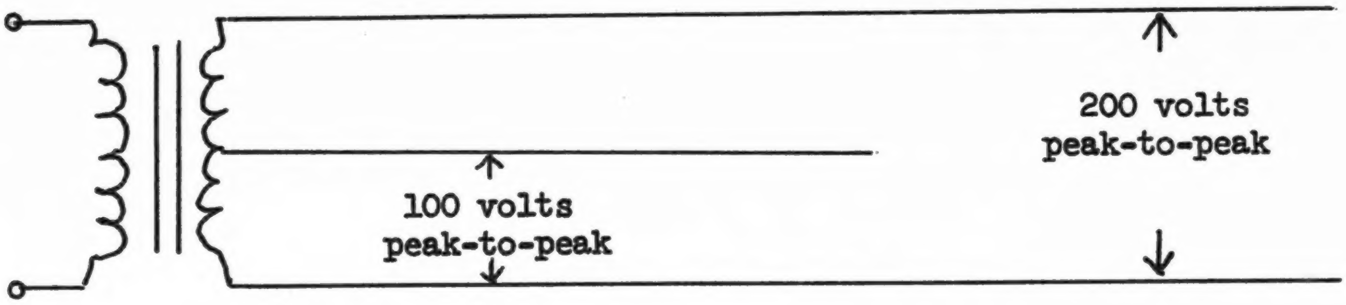
The following items (7-8) are advantages or disadvantages characteristic of either conventional full-wave rectifiers or bridge rectifiers (assuming a similar transformer is used). Mark the item:

a. if it is an advantage of a conventional full-wave rectifier.
b. if it is an advantage of a bridge rectifier.
c. if it is a disadvantage of a conventional full-wave rectifier.
d. if it is a disadvantage of a bridge rectifier.

7. Requires lower PIV diode rating for a given output voltage.

8. Delivers twice the output voltage for a given transformer.

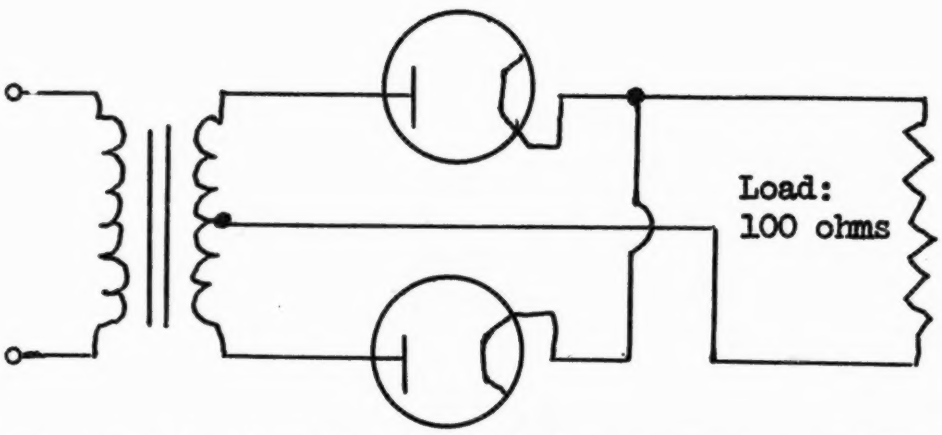
9. For this application the transformer shown below is used for the following question. CAUTION: Note that the voltage is given in peak-to-peak volts.



The rectifier rating is given to the left of the schematic diagram below. Mark the item:

a. if the diode fails voltage rating.
b. if the diode fails current rating.
c. if the diode fails voltage and current rating.
d. if the diode meets the requirements.

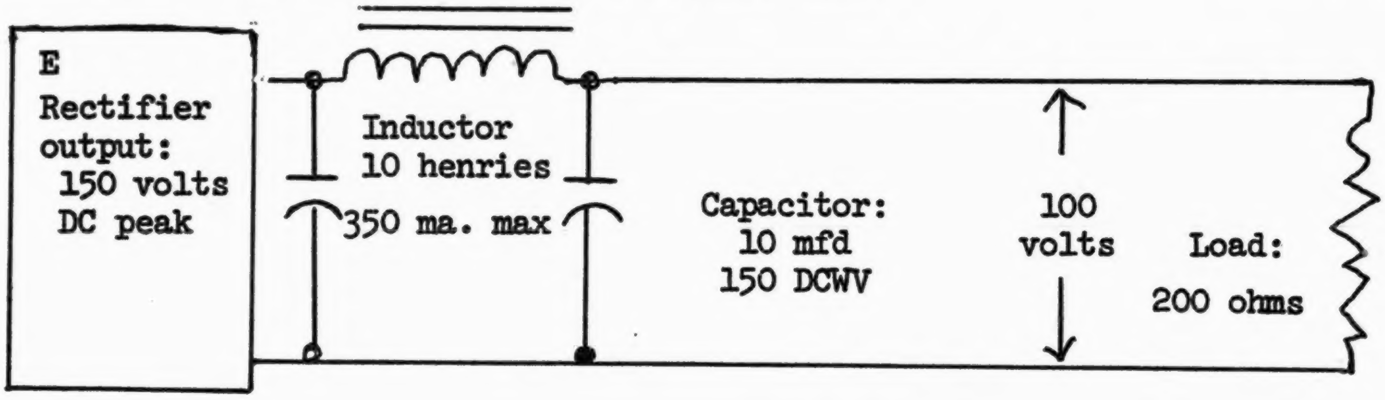
PLEASE REFER TO DIAGRAM ON FOLLOWING PAGE.


Load:
100 ohms

Two diodes, each
rated at:
90 PIV
450 ma. max

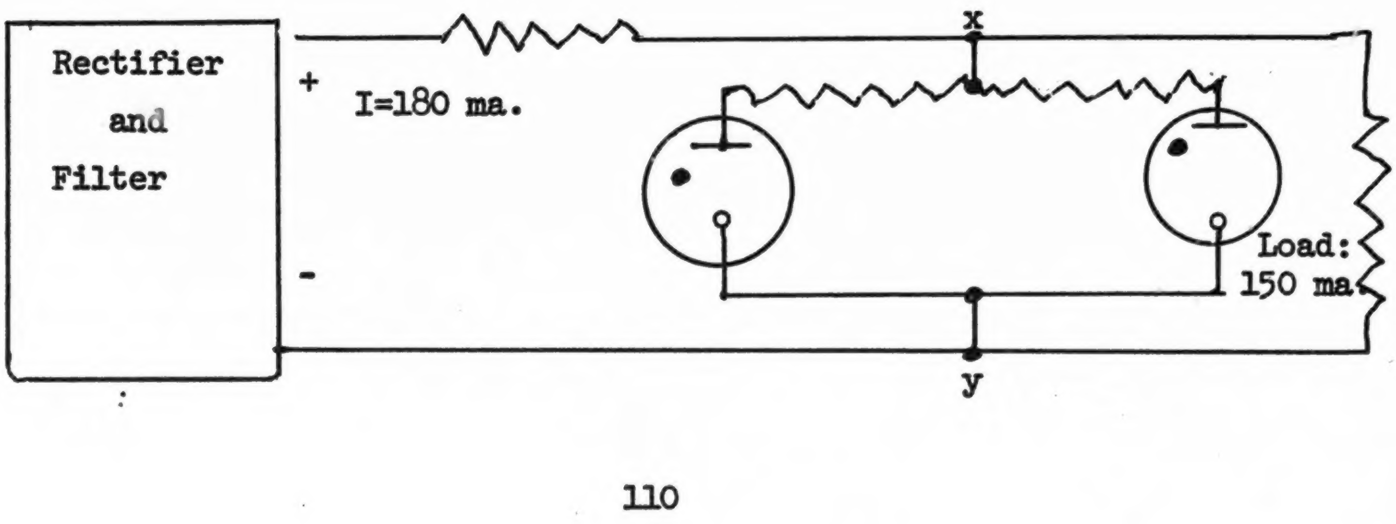
10. The filter circuit shown below has the indicated component specifications and lead requirements. For the circuit mark:

    a. if the inductor fails current rating.
    b. if the capacitor fails voltage rating.
    c. if the inductor and capacitor fail requirements.
    d. if the circuit meets the requirements.


E
Rectifier
output:
150 volts
DC peak
Inductor
10 henries
350 ma. max
Capacitor:
10 mfd
150 DCWV
100
volts
Load:
200 ohms

11. In the following problem two 75 volt glow-discharge regulator tubes with a 5 to 40 ma. current rating are used in a parallel circuit. Determine the total voltage between point x and point y in the schematic diagram below and determine the current in each of the tubes. Select the correct answer for the circuit from the following:

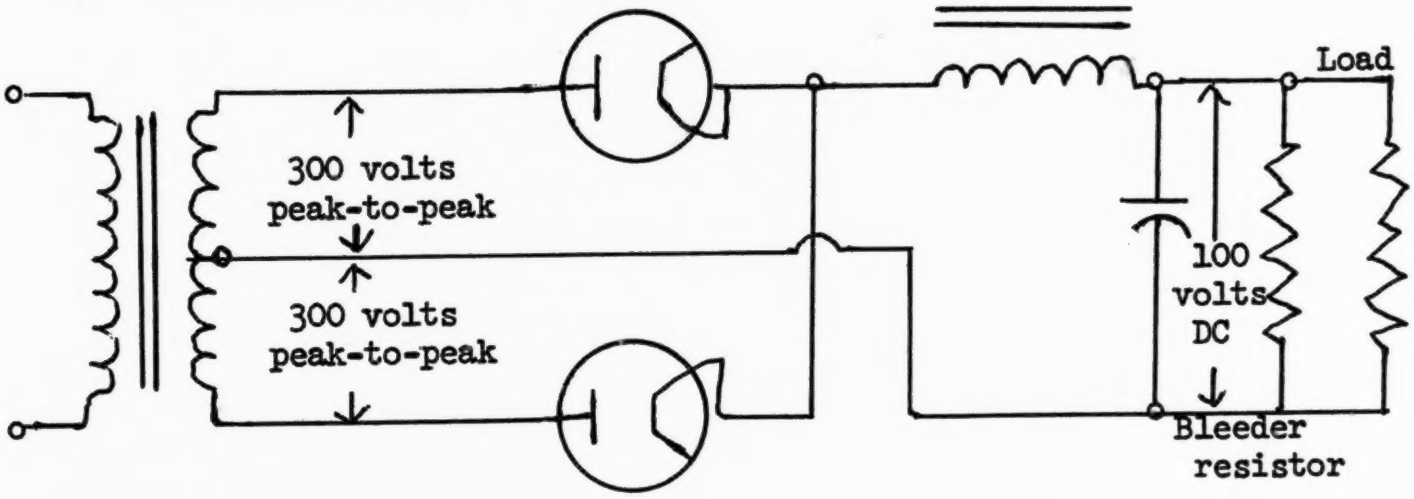
    a. 75 volts, 15 ma.
    b. 75 volts, 30 ma.
    c. 150 volts, 15 ma.
    d. 150 volts, 30 ma.


Rectifier
and
Filter
+
-
I=180 ma.
x
y
Load:
150 ma.

12. How many, if any, of the following regulators produce a fixed output voltage? Mark each correct response on your answer sheet.

  a. glow-discharge
  b. grid-controlled tube
  c. zener diode

Determine if the components of the power supply given below will provide 100 volts DC at 10 ma. to a load


300 volts peak-to-peak
300 volts peak-to-peak
Load
100 volts DC
Bleeder resistor

Select from the following answers the one that applies to each component (13-14).

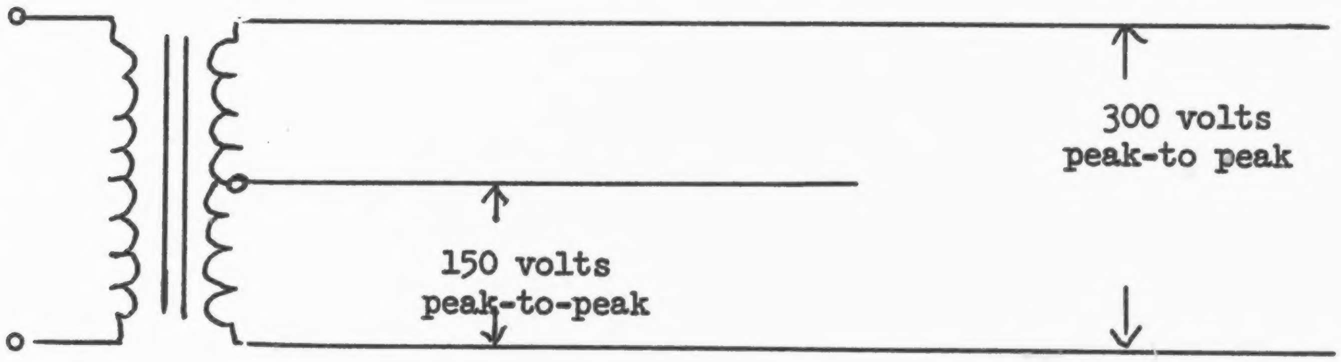
  a. current rating exceeded
  b. voltage rating exceeded
  c. power rating exceeded
  d. meets the requirements

13. Choke:
  5 henries
  50 ma. max

14. Bleeder resistor:
  10,000 ohms
  0.5 watt

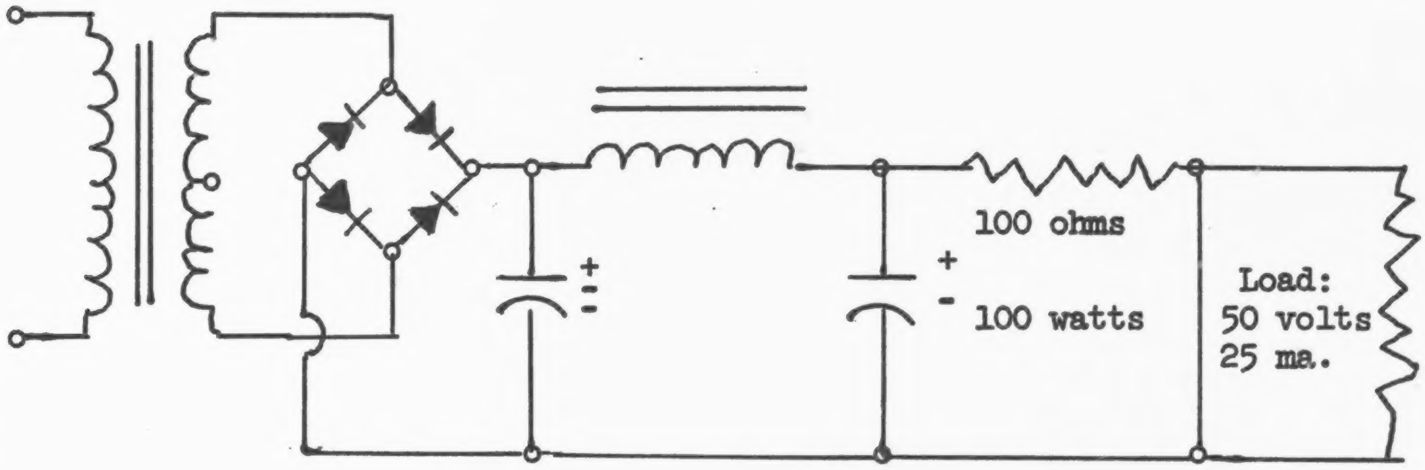
For the application that follows (15-16) the same transformer is used for three different circuits. Assume the following:

1. The transformer voltage output is 300 volts peak-to-peak across the total secondary high voltage winding and 150 volts peak-to-peak from the center tap to either end.
2. The filter output is 100 volts DC voltage.


300 volts
peak-to peak
150 volts
peak-to-peak

Select from the following answers the one that applies to each component:

a. voltage rating exceeded
b. current rating exceeded
c. voltage and current rating exceeded
d. meets the circuit requirements


+
-
+
-
100 ohms
100 watts
Load:
50 volts
25 ma.

15. Diode:
    100 PIV
    1 amp

16. Inductor:
    3.henries
    1 amp max

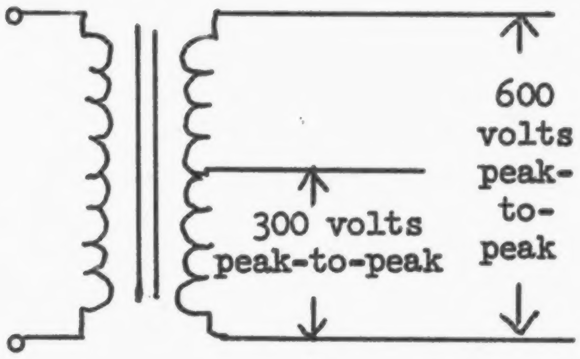
Draw a schematic diagram of a power supply on the separate answer sheet (selecting the components from the items given below (17-20). Mark the letter of each component you select on your answer sheet. Construct the power supply with as many components as necessary, but keep the number to a minimum, to meet the following requirements:

1. The rectifier must produce a 300 volt peak DC output (do not use a voltage doubler or half-wave rectifier).

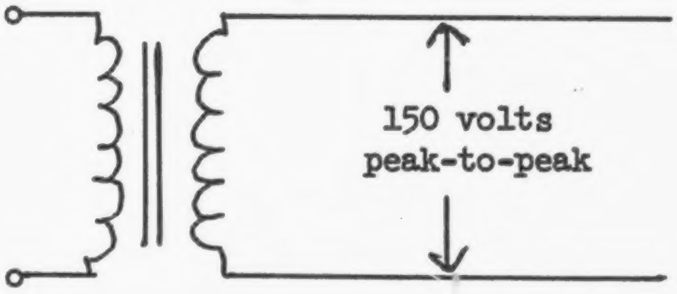
2. The filter must be a choke-input filter (assume that the filter output will be 200 volts DC at 150 ma.).

3. The load requires a regulated 150 volts DC at 125 ma. (Use glow-discharge tube(s) with an operating voltage of 75 volts and an operating current range from 5 to 40 ma.)

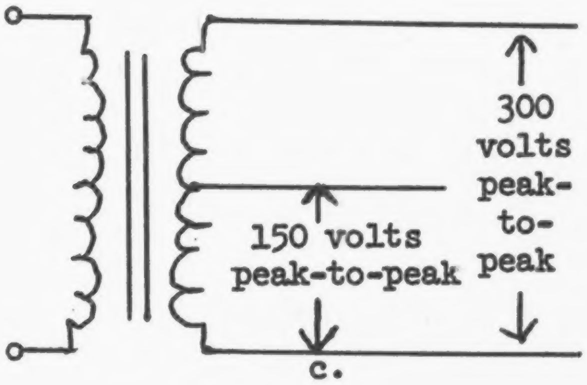
17. Transformer


600 volts peak-to-peak
300 volts peak-to-peak

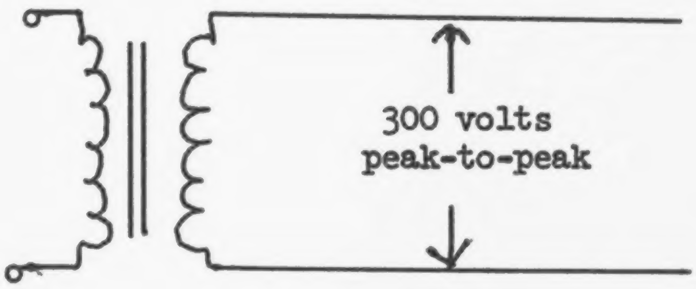
a.


150 volts peak-to-peak

b.

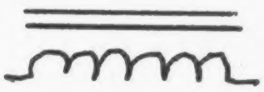

300 volts peak-to-peak
150 volts peak-to-peak

c.

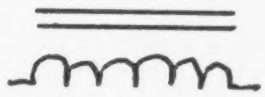

300 volts peak-to-peak

d.

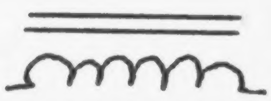
18. Filter, part I



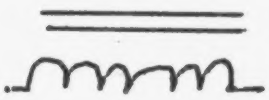
1 henry
200 ma.
a.



10 henries
25 ma.
b.



50 henries
100 ma.
c.

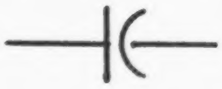


20 henries
50 ma.
d.

19. Filter, part II

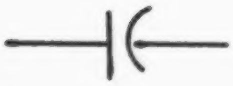
100 mfd
150 DCWV

a.



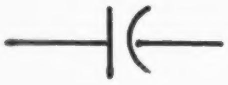
40 mfd
250 DCWV

b.



15 mfd
100 DCWV

c.



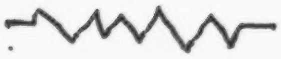
1 mfd
175 DCWV

d.

20. Regulator

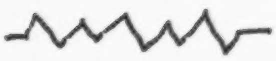
15 watts
527 ohms

a.



15 watts
400 ohms

b.



15 watts
333 ohms

c.

15 watts
250 ohms

d.

APPENDIX G

POST-TEST, POWER SUPPLIES

EXAMINATION, POWER SUPPLIES

Version III, January 1967

For the following questions (1-2), select the appropriate definition on the right:

1. Rectifier
2. Voltage regulator

a. A circuit used to eliminate undesired voltage variations through the use of capacitance and inductance.

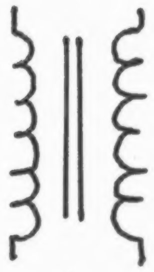
b. A circuit used to change AC voltage input to a DC voltage output.

c. An instrument used to reduce current to a desired value or to produce a specified voltage drop.

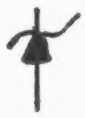
d. A device using the principle of mutual inductance having a primary winding connected to a voltage source and one or more secondary windings connected to a load(s).

e. A circuit utilizing component parts to maintain a given output voltage.

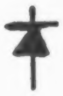
The next four questions (3-6) require the correct matching of the numbered terms with the schematic drawing given above them.



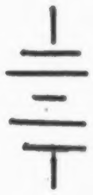
a



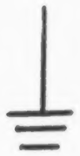
b



c



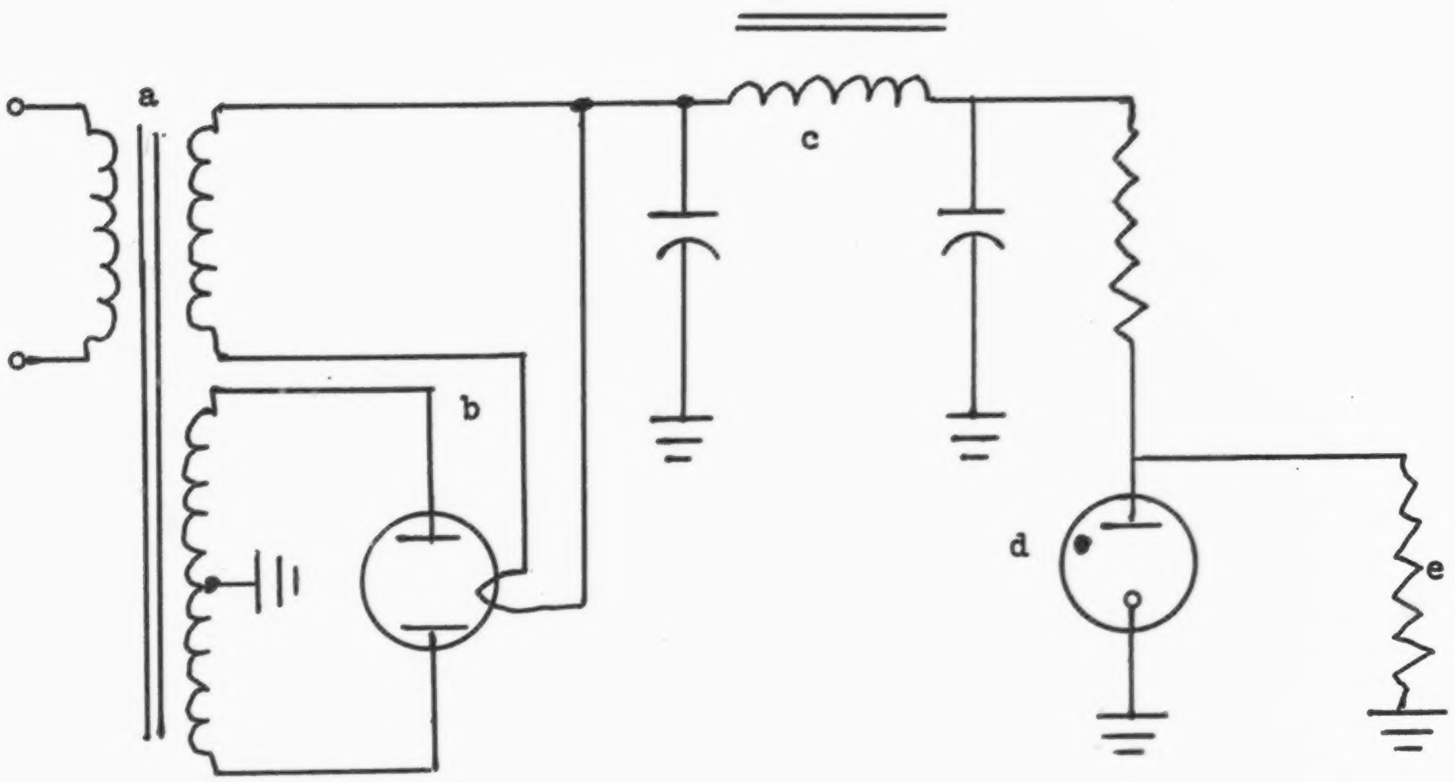
d



e

3. Transformer
4. Selenium rectifier
5. Zener diode
6. Battery

The schematic diagram below is of a typical power supply.



The diagram has been divided into five sections. In the next two questions (7-8) identify the section indicated.

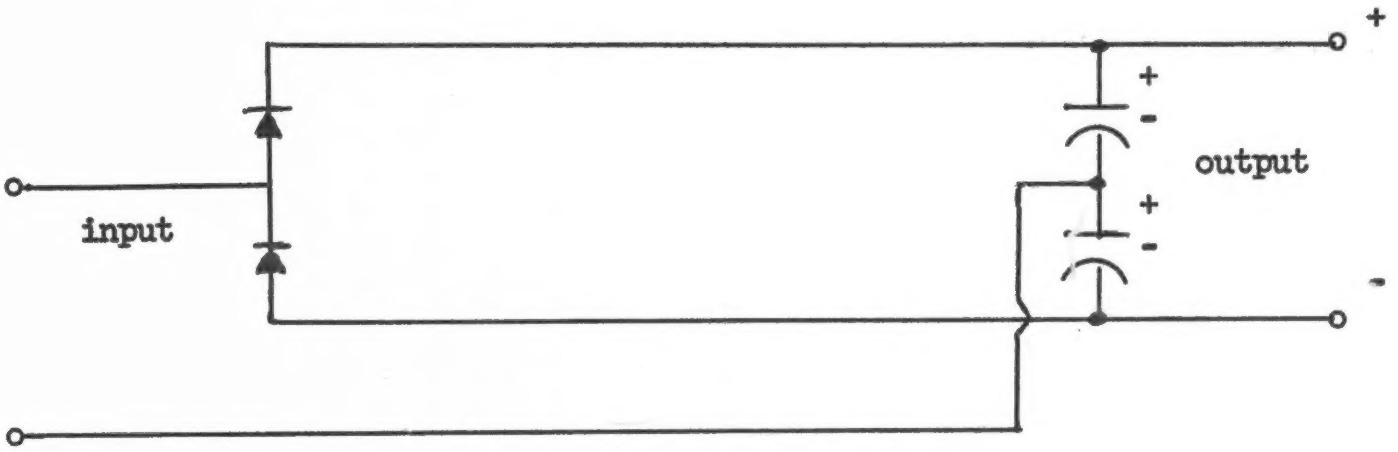
7. Filter

8. Transformer

For the following questions (9-10), select the EIA color code for the appropriate transformer winding.

9. High voltage secondary winding	a. Black
10. Rectifier filament winding	b. Yellow
	c. Red
	d. Yellow-Blue
	e. Red-Yellow

11. The circuit below has a 150 volt peak-to-peak AC input.



Determine which of the following answers is the correct magnitude of the DC output voltage. CAUTION: The AC input voltage is given in peak-to-peak volts.

a. 75 volts

b. 150 volts

c. 300 volts

d. 450 volts

12. Which of the following definitions gives the best description of a selenium rectifier?

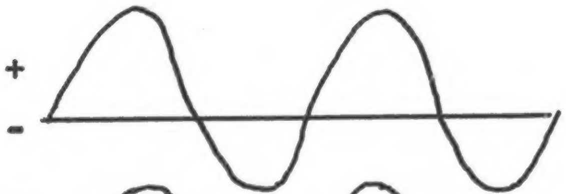
a. a vacuum tube with a selenium cathode indirectly heated by a filament causing rectified current flow from cathode to plate.

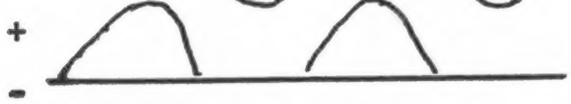
b. a parallel connection of selenium plates with a high resistance to current flow in one direction and low resistance in the opposite direction.

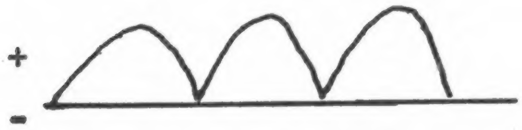
c. an aluminum encased selenium electrode in an electrolyte solution producing rectified current flow.

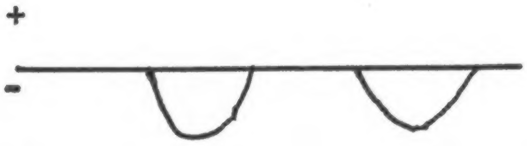
d. a series of iron disks coated on one side with selenium having a high resistance to current flow in one direction and low resistance in the opposite direction.

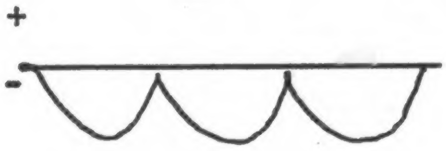
13. Select each of the following wave forms, if any, that represents the unfiltered output of a half-wave rectifier.

a. 

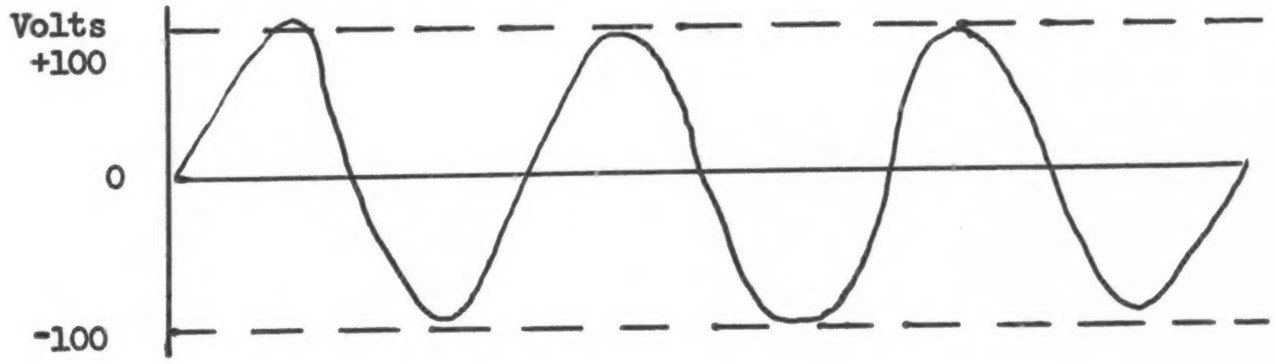
b. 

c. 

d. 

e. 

14. For the application that follows, a transformer with the output wave form shown below is used.



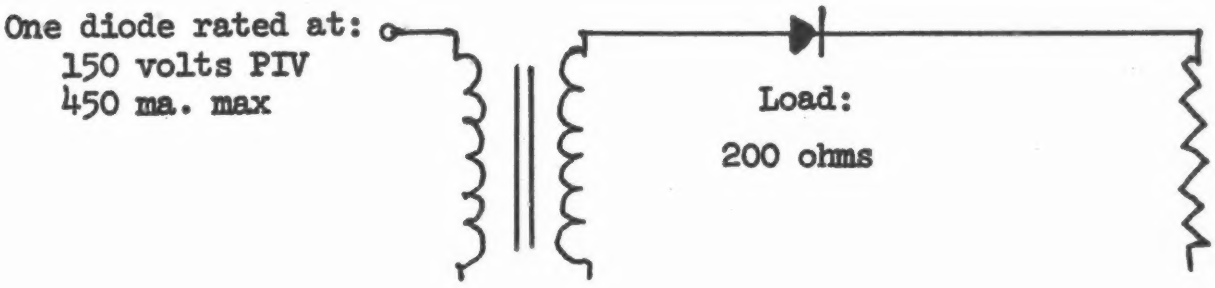
The ratings for the individual rectifier (diode) in the circuit is given to the left of the schematic diagram below. For the question mark:

a. if the diode fails voltage rating.

b. if the diode fails current rating.

c. if the diode fails voltage and current rating.

d. if the diode meets the requirements.



One diode rated at:
150 volts PIV
450 ma. max

Load:

200 ohms

15. Which of the following definitions gives the best description of a bridge rectifier circuit?

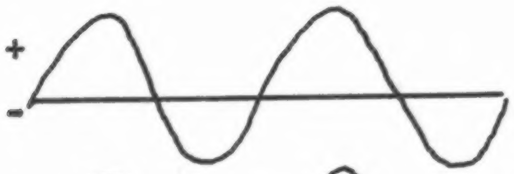
   a. a circuit with four diodes arranged in a diamond shape serving as a power supply.

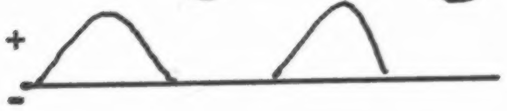
   b. a circuit with two diodes arranged to bridge electron flow into a load resistance requiring a DC current flow.

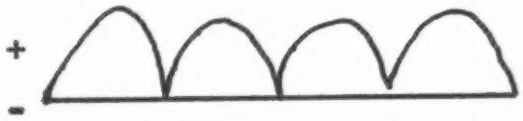
   c. a circuit with four diodes arranged to bridge only positive electrons of an AC current thereby producing an electronic full-wave rectified DC output.

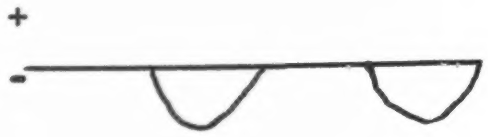
   d. a circuit with four diodes arranged such that AC current flows through two diodes at a time producing a pulsating DC output.

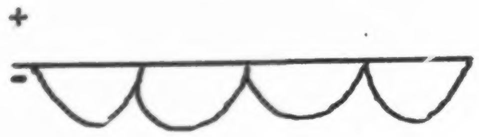
16. Select each of the following wave forms, if any, that represents the unfiltered output of a full-wave rectifier.

a.


b.


c.


d.


e.


The following items (17-20) are advantages or disadvantages characteristic of either conventional full-wave rectifiers or bridge rectifiers (assuming a similar transformer is used). Mark the item:

   a. if it is an advantage of a conventional full-wave rectifier.

   b. if it is an advantage of a bridge rectifier.

   c. if it is a disadvantage of a bridge rectifier.

17. Requires lower PIV diode rating for a given output voltage.

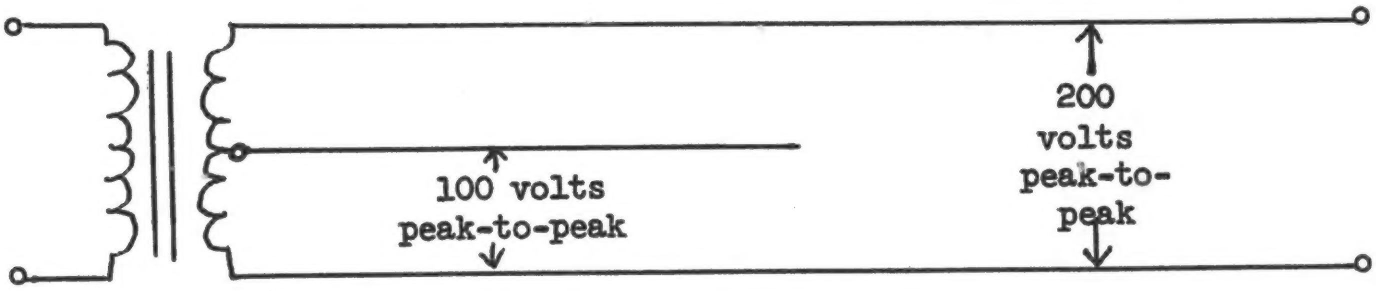
18. Requires two diodes.

19. Requires a center tapped transformer.

20. Delivers twice the output voltage for a given transformer.

21. On the separate answer sheet there are two circuits shown in schematic diagrams with unattached lines around each circuit. Show the electron flow in both diagrams by placing arrows on these lines, and circle the lines where there is no flow.

22. For this application the transformer shown below is used for the following question. CAUTION: Note that the voltage is given in peak-to-peak volts.



The rectifier rating is given to the left of the schematic diagram below. Mark the item:

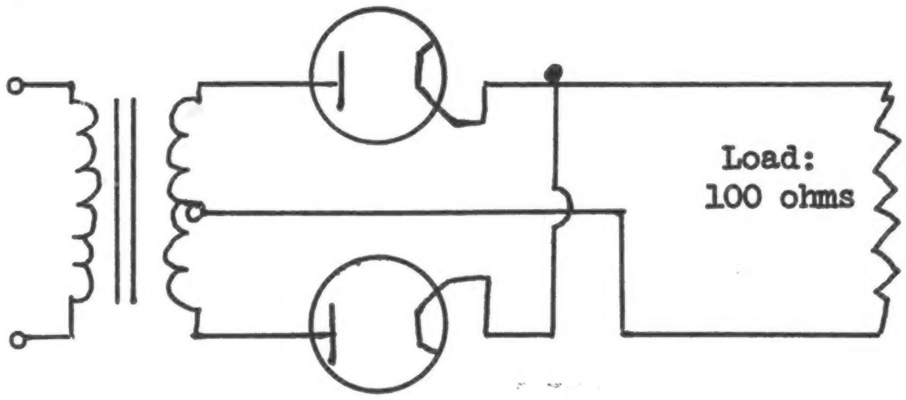
a. if the diode fails voltage rating

b. if the diode fails current rating

c. if the diode fails voltage and current rating

d. if the diode meets the requirements

Two diodes, each
rated at:
90 PIV
450 ma. max

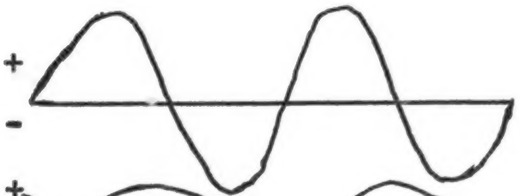


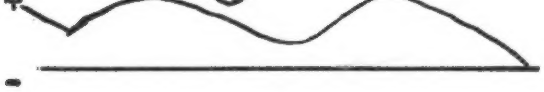
The following items (23-24) are characteristic of either a capacitive-input filter or a choke-input filter. Identify each as either capacitive (mark a on your answer sheet) or inductive (mark b on your answer sheet).

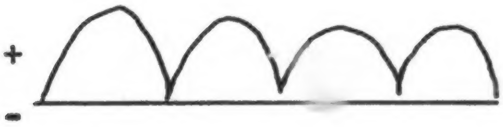
23. Best for filtering heavy loads

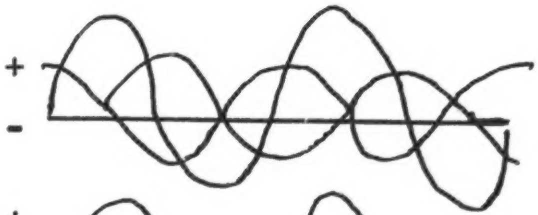
24. The output closely approximates the peak voltage of the input if the load is light.

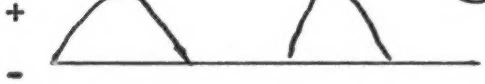
25. Select each of the following wave forms, if any, that represents the voltage wave form of the output of a half-wave rectifier, with a simple capacitor filter in parallel with the load.

a.


b.


c.


d.


e.


26. Select the alternative below that best describes the effect of a choke-input filter on current flow.

a. regulates the current well, but draws high peak currents from the rectifier

b. increases current flow from the rectifier and, therefore, has a greater output voltage from the choke than from the rectifier

c. cannot regulate or filter well under heavy loads

d. allows a rectifier with a low peak current rating, as the choke makes efficient use of current from the rectifier

27. Select each alternative, if any, that describes the purpose of a bleeder resistor.

a. The bleeder resistor aids the diode regulation system by bleeding of excess current during operation of the circuit.

b. The bleeder resistor provides a minimum load for a power supply to prevent excess output voltage when the load is removed.

c. The bleeder resistor is important for safety in a power supply as it bleeds off current from filter capacitors when the power supply is turned off.

d. The bleeder resistor enables the circuit to operate with voltage stability under heavy loads.

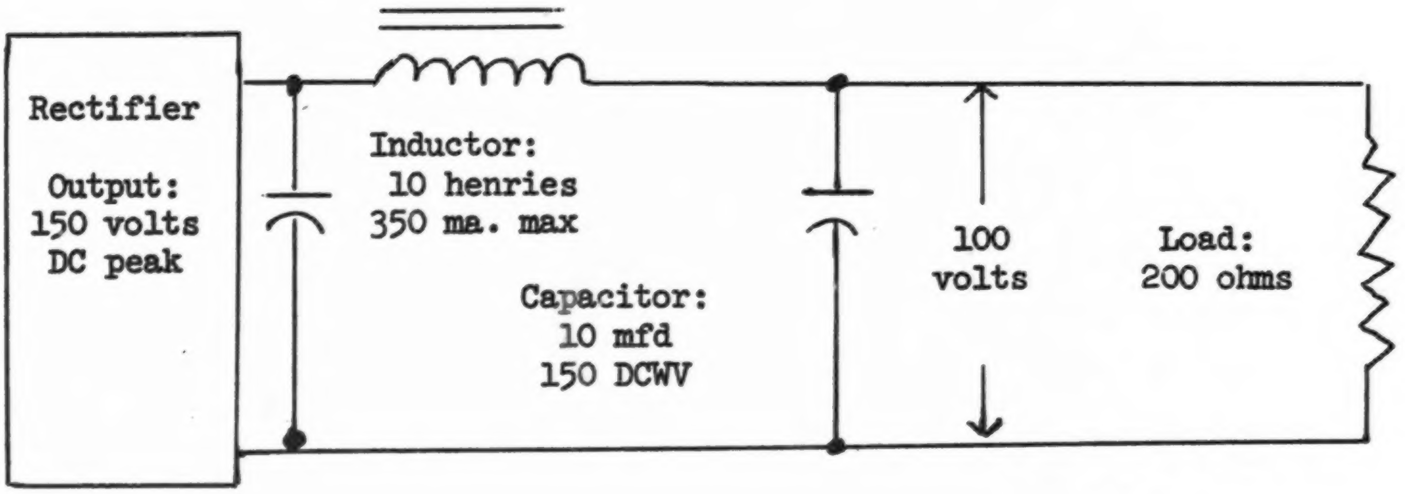
28. The filter circuit shown below has the indicated component specifications and load requirements. For the circuit mark:

a. if the inductor fails current rating.

b. if the capacitor fails voltage rating.

c. if the inductor and capacitor fail requirements.

d. if the circuit meets the requirements.


Rectifier
Output:
150 volts
DC peak
Inductor:
10 henries
350 ma. max
Capacitor:
10 mfd
150 DCWV
100
volts
Load:
200 ohms

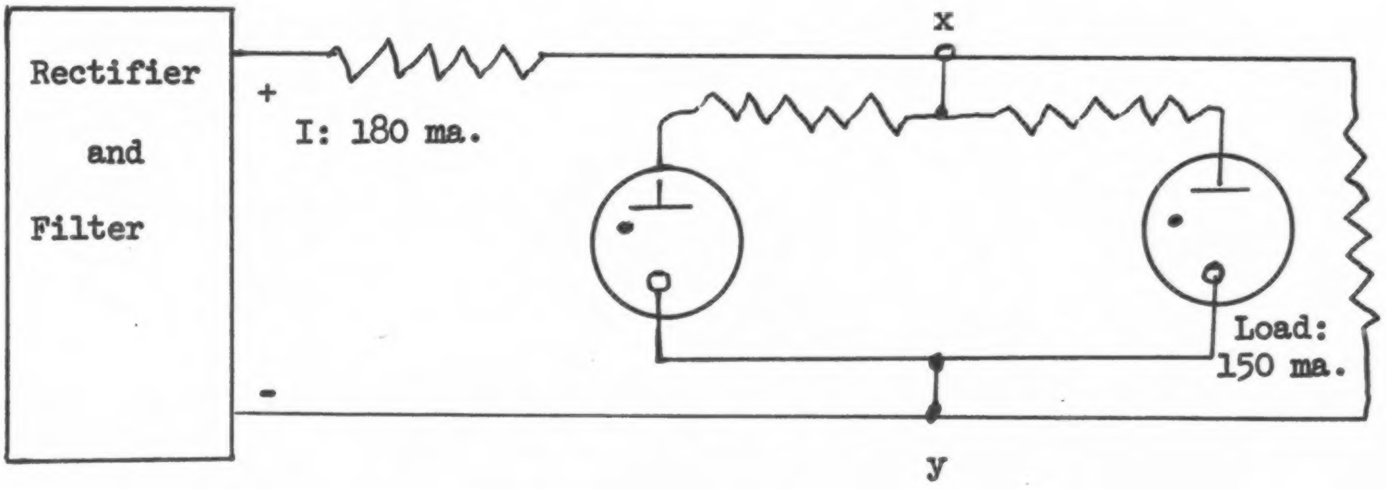
29. In the following problem two 75 volt glow-discharge regulator tubes with a 5 to 40 ma. current rating are used in a parallel circuit. Determine the total voltage between point x and point y in the schematic diagram below and determine the current in each of the tubes. Select the correct answer for the circuit from the following:

a. 75 volts, 15 ma.

b. 75 volts, 30 ma.

c. 150 volts, 15 ma.

d. 150 volts, 30 ma.


x
Rectifier
and
Filter
+
-
I: 180 ma.
Load:
150 ma.
y

The following items (30-32) are regulator characteristics. Some apply to glow-discharge tubes, some to grid-controlled tubes, some to zener diodes, and some to more than one type of regulator. Select from the following answers each one that applies to the regulator characteristics given below:

a. glow-discharge tube

b. grid-controlled tube

c. zener diode

30. Produces a fixed output voltage

31. Capable of continuous variation of voltage output

32. Provides the simplest method of regulation

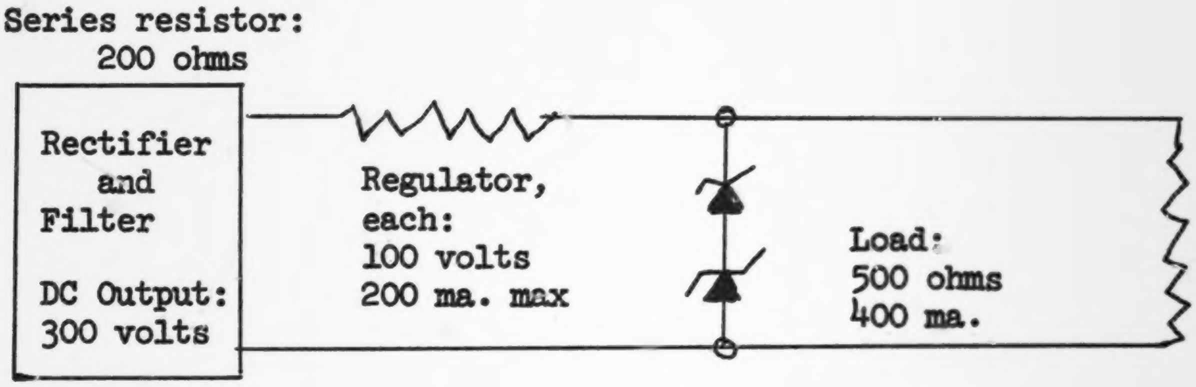
33. The voltage regulator circuit shown below has the indicated component specifications and load requirement. For the circuit mark:

a. if the series resistor is too large.

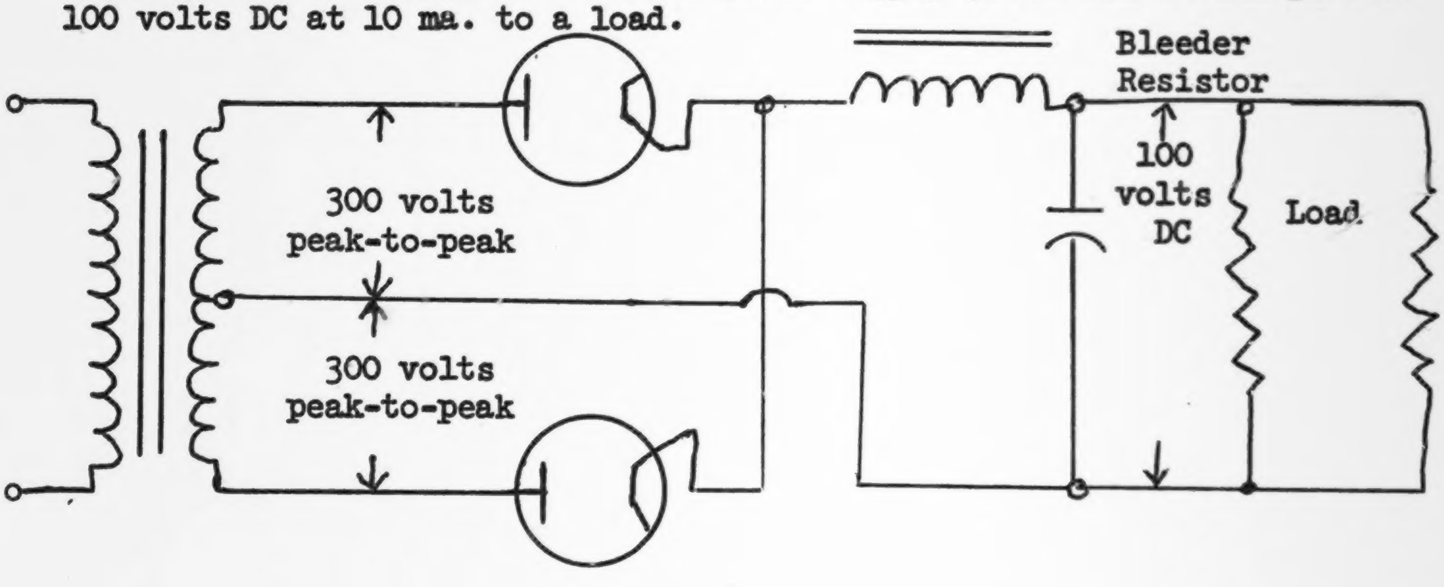
b. if the series resistor is too small.

c. if the series resistor causes varied current.

d. if the circuit meets the requirements.


Series resistor:
200 ohms
Rectifier and Filter
DC Output: 300 volts
Regulator, each:
100 volts
200 ma. max
Load:
500 ohms
400 ma.

Determine if the components of the power supply given below will provide 100 volts DC at 10 ma. to a load.


300 volts peak-to-peak
300 volts peak-to-peak
Bleeder Resistor
100 volts DC
Load

Select from the following answers the one that applies to each component (34-37):

a. current rating exceeded

b. voltage rating exceeded

c. power rating exceeded

d. meets the requirements

34. Diode:
50 ma. max
450 PIV

35. Capacitor:
20 mfd
200 DCWV

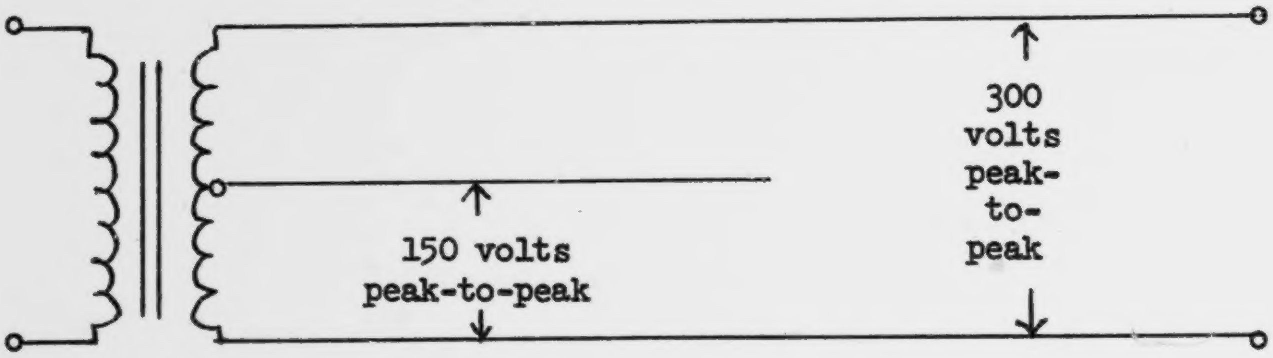
36. Choke:
5 henries
50 ma. max

37. Bleeder resistor:
10,000 ohms
0.5 watt

For the application that follows (38-41) the same transformer is used for three different circuits. Assume the following:

1. The transformer voltage output is 300 volts peak-to-peak across the total secondary high voltage winding and 150 volts peak-to-peak from the center tap to either end.

2. The filter output is 100 volts DC voltage.



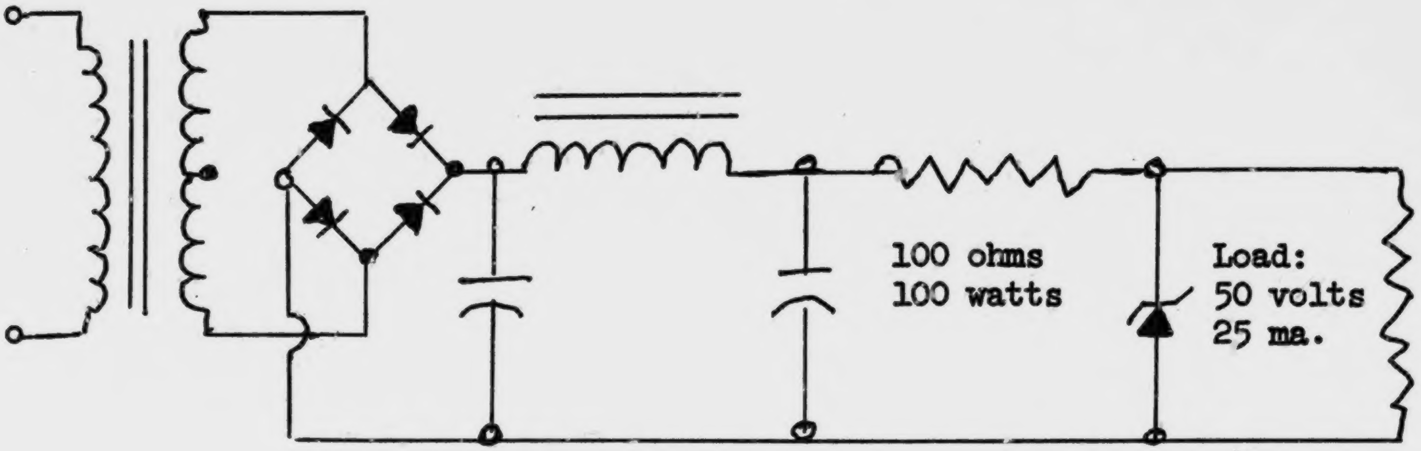
Select from the following answers the one that applies to each component:

a. voltage rating exceeded

b. current rating exceeded

c. voltage and current rating exceeded

d. meets the circuit requirements



38. Diode:
    100 PIV
    1 amp

39. Capacitors:
    20 mfd
    350 DCWV

40. Inductor:
    3 henries
    1 amp max

41. Regulator diode:
    50 volts
    1 ma. max

Draw a schematic diagram of a power supply on the separate answer sheet (selecting the components from the items given below--42-46). Mark the letter of each component you select on your answer sheet. Construct the power supply with as many components as necessary, but keep the number to a minimum, to meet the following requirements:

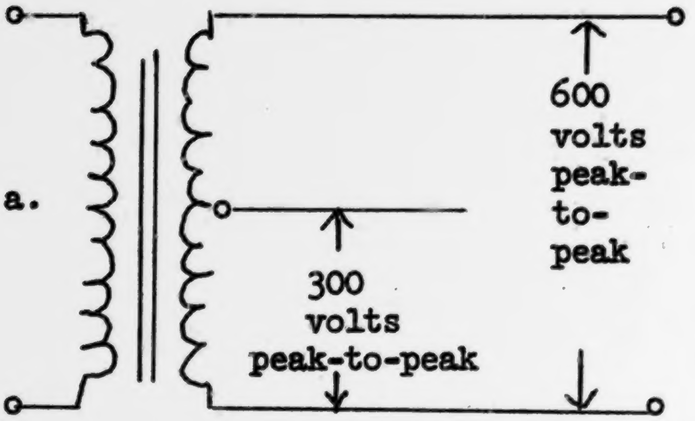
1. The rectifier must produce a 300 volt peak DC output (do not use a voltage doubler or half-wave rectifier).

2. The filter must be a choke-input filter (assume that the filter output will be 200 volts DC a 150 ma.).

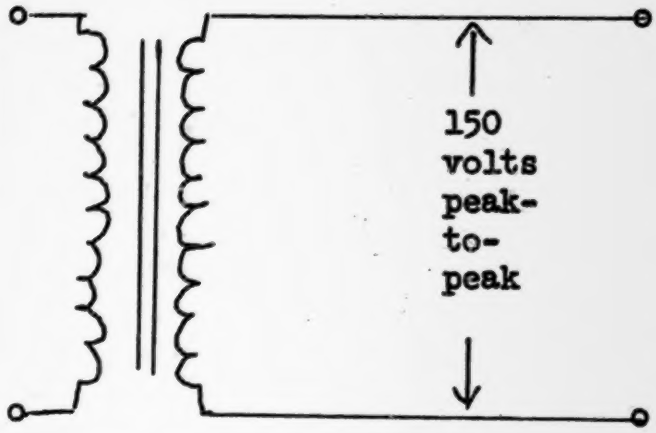
3. The load requires a regulated 150 volts DC at 125 ma. (use glow-discharge tube(s) with an operating voltage of 75 volts and an operating current range from 5 to 40 ma.).

42. Transformer

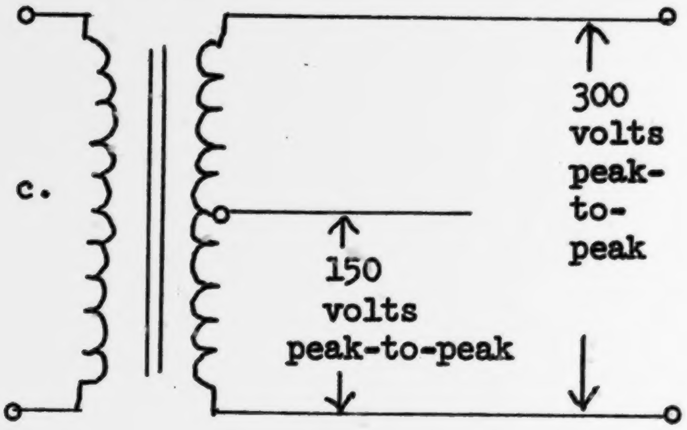
a.


600
volts
peak-
to-
peak
300
volts
peak-to-peak

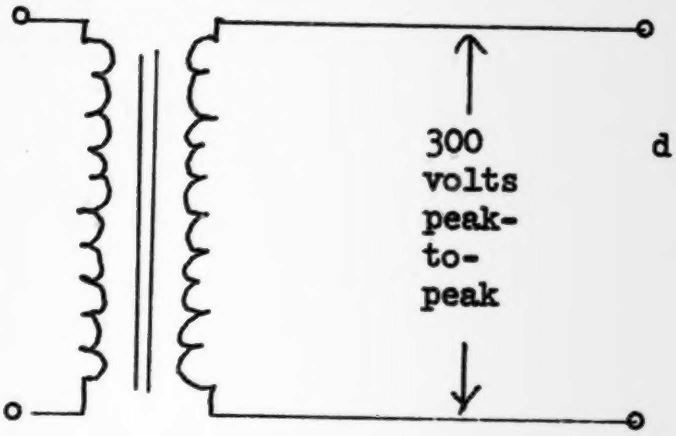
b.


150
volts
peak-
to-
peak

c.

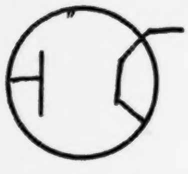

300
volts
peak-
to-
peak
150
volts
peak-to-peak

d.


300
volts
peak-
to-
peak

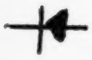
43. Rectifier

a.



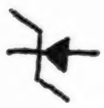
100 ma. max
750 PIV

b.



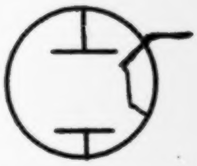
200 ma. max
400 PIV

c.



500 ma.
100 volts

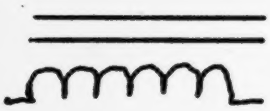
d.



150 ma. max
200 PIV

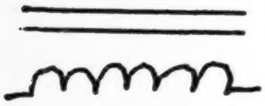
44. Filter, part I

a.



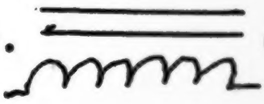
1 henry
200 ma.

b.



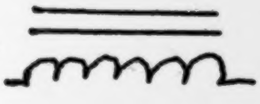
10 henries
75 ma.

c.



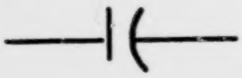
50 henries
100 ma.

d.

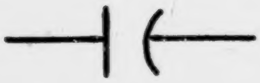


20 henries
50 ma.

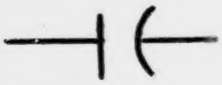
45. **Filter, part II**

a. 

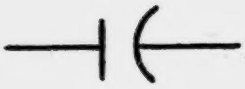
100 mfd
150 DCWV

b. 

40 mfd
250 DCWV

c. 

15 mfd
100 DCWV

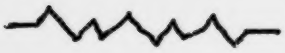
d. 

1 mfd
750 DCWV

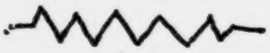
46. **Regulator**

a.

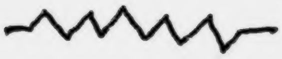
15 watts
527 ohms

b. 

15 watts
400 ohms

c. 

15 watts
333 ohms

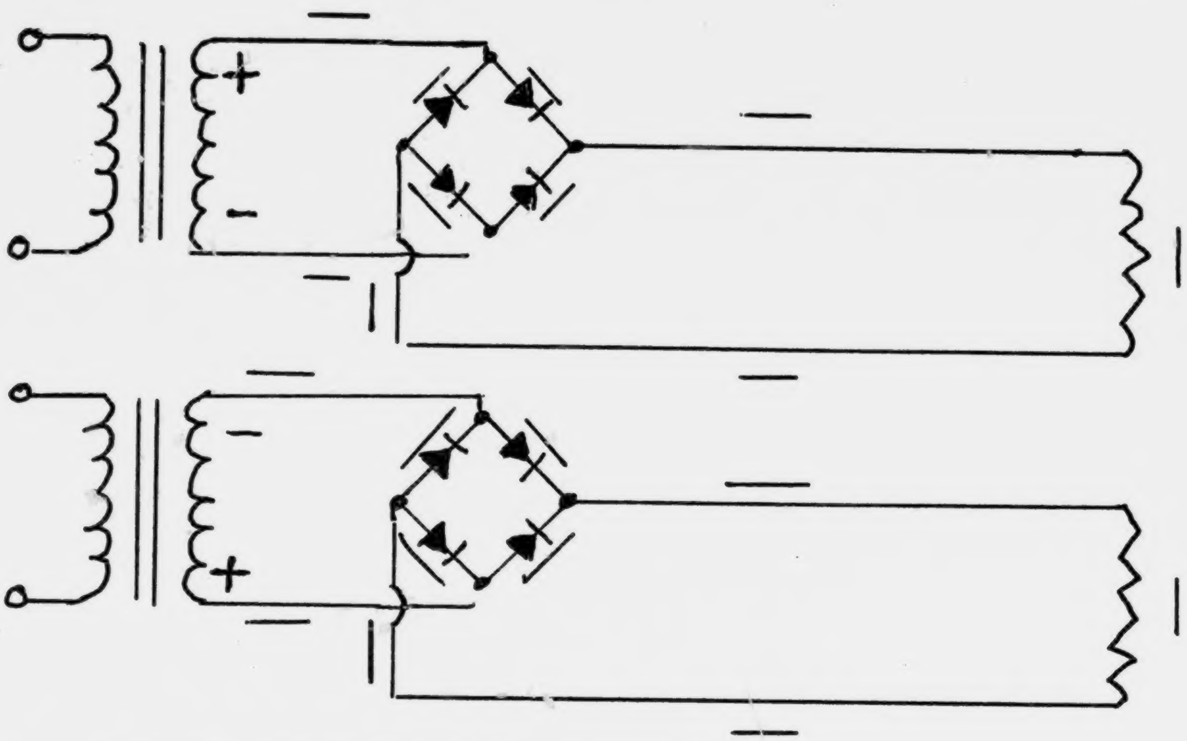
d. 

15 watts
250 ohms

ANSWER SHEET, POWER SUPPLIES

Version III, January 1967

21. Trace the electron flow in both diagrams below by placing arrows on the unattached lines. Circle the unattached lines where there is no flow.



42-46. Draw the schematic diagram below.

APPENDIX H

STUDENT QUESTIONNAIRE, POWER SUPPLIES

STUDENT QUESTIONNAIRE
POWER SUPPLIES UNIT

Directions: Please help us to improve this unit by answering the following questions. Your suggestions and general reactions will only be used for this purpose, so be as frank as you can. Thank you.

1. Name ________________________ Instructor's Name __________________

2. How many courses have you had before on electricity or electronics? ______

3. What is your approximate grade point average in the electricity or electronics courses you have completed? (A = 4.0) ______.

4. What was your overall grade point average in high school? (A = 4.0) ______.

5. After you finish school do you plan to enter the electronics field? (Check one) ___1. definitely yes, ___2. probably, ___3. uncertain, ___4. probably not, ___5. definitely not.

6. How would you rate your interest in the general field of electronics? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low.

7. Before the unit how would you rate your interest in the specific topic of electronics? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low.

8. After this unit how would you rate your interest in the specific topic of electronics? ___1. high, ___2. above average, ___3. average, ___4. below average, ___5. low

9. With respect to the topics covered in this unit, I was: ___1. extremely interested, ___2. interested, ___3. neutral, ___4. bored, ___5. extremely bored.

10. If more material of this type were available, I would: ___1. definitely study it on my own, ___2. probably study it on my own, ___3. not know whether to study it, ___4. probably not study it on my own, ___5. definitely not study it on my own.

11. In general, I think the field of electronics is: ___1. exciting, ___2. interesting, ___3. of average interest, ___4. uninteresting, ___5. dull.

12. The practical value of the information in the unit was: ___1. very great, ___2. above average, ___3. average, ___4. below average, ___5. very little.

13. If a friend of mine were studying electronics, I would urge him to: ___1. definitely study this topic, ___2. probably study this topic, ___3. be indifferent about this topic, ___4. probably avoid this topic, ___5. definitely avoid this topic.

14. I felt the post-test (completed today) was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

15. I felt the pre-test (completed earlier) was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

16. Most of the material treated during the unit was: ___1. too hard, ___2. hard, ___3. of average difficulty, ___4. easy, ___5. too easy.

17. Please make any suggestions on back of this sheet which you feel might assist in improving the unit, tests, etc.

APPENDIX I

INSTRUCTOR QUESTIONNAIRE, ELECTRONICS OR AUTO MECHANICS

INSTRUCTOR QUESTIONNAIRE
Performance Test Resource Unit

Directions: Please fill this out while your students are completing the post-test. Its only purpose is to improve the unit, so please be candid in your responses.

NAME______________________________ DATE____________________

Please give the name of the course and briefly describe it in a sentence or two.

The next three questions refer to the objectives in the unit. It will probably be necessary to refer to the attached xerox copy of the objectives.

1. Circle the numbers of the objectives which you planned to cover prior to commencing the unit.

   1 2 3 4 5 6 7 8 9 10 11 12 13 14

   15 16 17 18 19 20 21 22 23 24 25 26 27 28

   29

2. Circle the numbers of the objectives which you actually covered during the instructional period devoted to the unit.

   1 2 3 4 5 6 7 8 9 10 11 12 13 14

   15 16 17 18 19 20 21 22 23 24 25 26 27 28

   29

3. Please evaluate the quality of each objective according to the following scheme. If it should be retained circle it. If it should be deleted, put an X through it. If it should be modified or if you are uncertain, do neither.

   1 2 3 4 5 6 7 8 9 10 11 12 13 14

   15 16 17 18 19 20 21 22 23 24 25 26 27 28

   29

4. List any important topics which were omitted but should have been included.

5. How many hours (excluding the time for pre- and post-tests) did you actually devote to the unit? ________

6. Was this time: _____too long, _____about right, _____too short.

7. How would you rate the organization of the material you received? _____good, _____fair, _____poor.

8. Do you have any suggestions regarding how the organization of the material should be improved?

9. In general, what is your overall rating of the objectives given in the unit? _____excellent, _____good, _____average, _____fair, _____poor.

10. If your participation were again requested on a project in the same field but on a different topic, how would you respond? _____definitely participate, _____probably participate, _____uncertain, _____probably not participate, _____definitely not participate.

11. What are your subjective feelings about your class' response to the unit? _____enthusiastic, _____interested, _____neutral, _____uninterested, _____bored.

12. If a colleague of yours in a different school asked your advice regarding his participation in a project such as this, how would you advise him? _____definitely participate, _____probably participate, _____uncertain, _____probably not participate, _____definitely not participate.

13. How did you react to the idea of directing your teaching toward objectives which were given to you? For example, did you really try to treat these objectives, or did you teach the unit pretty much the way you ordinarily would? In other words, what are your feelings about "teaching to someone else's goals"?

14. Did you use any of the possible learning activities described in the unit? _____ If yes, how many? ____most, ____some, ____a few.

15. Can you suggest other learning activities which should be included?

16. Are there any additional comments which you wish to make regarding the project? Any criticisms, suggestions, feelings, etc. will be greatly appreciated.

APPENDIX J

MISCELLANEOUS FORMS USED TO COMMUNICATE WITH PROJECT PARTICIPANTS

AN INVITATION TO PARTICIPATE

IN A RESEARCH PROJECT

In connection with the conduct of a research project sponsored by the U.S. Office of Education (under provisions of the Vocational Education Act of 1963), UCLA is currently securing teacher-participation in an investigation to be conducted in the very near future. A summary of the project is attached. We hope that you might be interested in participating in the investigation which, incidentally, has the approval of your district's administrators. If, having read the summary, the project appears to be one in which you are interested in participating, please fill out the teacher portion (upper half) of the Teacher-Specialist Sign-Up Sheet and return it in the stamped self-addressed envelope. Also return the signed patent release form which is a routine university document which must be filed in order to pay you the $50 honorarium provided for participants.

The specifics of your participation are as follows: First, you must have at least two sections of a course in which a nine hour instructional unit on either (a) carburetion or (b) electronic power supply could be taught this year. The topics covered in each unit are described on an attached sheet. Then return the two forms suggested here, having initially cleared with your principal or department head as necessary. Then our staff will contact you to set up a specific time for pre-testing and for the actual conduct of the unit. A skilled industrial specialist will be located to instruct one of your classes for this period. Approximately two weeks prior to the time identified for the unit, the resource materials and instructional objectives will be given to you so that you can make your instructional plans. Carburetors or power supply kits will also be provided at this time. Then during the teaching period you will instruct one of your classes while the industrial specialist instructs another.

Results of your pupils' performance (in both classes) will be given to you, along with a report of the total study. Beyond this, however, your particular results will not be revealed to any one in the district. Complete anonymity for each participant will be guaranteed. We are anxious to investigate groups of instructors, not a particular instructor.

If you have any questions regarding the project, please write or phone (collect) either

W. James Popham
Associate Professor
Department of Education
UCLA
Los Angeles, California
478-9711, ext. 7031

Richard S. Moore
c/o W. James Popham
478-9711, ext. 7303

AUTO MECHANICS - ELECTRONICS

RESEARCH PROJECT SUMMARY

One of the more difficult problems associated with improving teacher education is that it is difficult to locate a defensible criterion of teaching performance once the teacher education candidate has completed his professional preparation sequence. It is difficult to use ratings and other subjective judgments because of the variability in these evaluations. Further, the difficulty of contrasting teacher education programs according to their ability to instructors who can promote learner achievement is complicated by the fact that different teachers usually have different instructional objectives. Comparing teachers with dissimilar goals is difficult if not impossible. In attempting to cope with this problem, the United States Office of Education has recently supported a series of research projects at UCLA which are designed to produce a heretofore untried method of assessing the quality of teacher education programs through the use of a performance test of teaching proficiency. If this method has merit, we hope to use it to improve the quality of the teacher education program at UCLA and, hopefully, elsewhere. We see no possibility that the approach will be used for the assessment of individual teachers for a number of uncontrollable variables (for example, pupil ability) preclude such a use of the assessment technique. However, for groups of teachers the method may prove sufficiently defensible to allow us to test variations in pre-service and in-service teacher education sequences.

Briefly, we provide a set of extremely explicit teaching goals (stated in terms of learner behavior) designed to cover approximately nine hours worth of instruction. These objectives are given to the teacher along with a series of resource materials and a collection of possible learning activities which the teacher may or may not wish to employ to achieve the objectives. The only thing that we ask of the teachers who participate in the study (and, obviously, voluntary participation is requisite here) is that they attempt to accomplish the instructional objectives which are given for the unit of work. In other words, we ask the teachers to attempt to accomplish given ends using whatever means they wish to employ.

Members of our project staff administer a 15-minute pre-test before the unit of instruction is commenced and, at the end of the unit, a 50-minute post-test. These tests are based explicitly on the objectives which have been given to the teacher. By using measures of pupil growth towards the objectives, we can provide an index of teaching competence on this dimension, i.e., the ability to accomplish pre-specified instructional objectives. Thus far we have developed such performance tests in the fields of auto mechanics (more specifically, carburetion) and electronics (more specifically, electronic power supplies).

We are interested in determining how individuals with markedly different backgrounds respond to this kind of an instructional task. Accordingly, we are inviting a group of experienced public school teachers and experienced industrial specialists to participate in an early trial of our materials. The industrial specialists will be skilled tradesmen from industry who are familiar with the subject matter but have never previously taught. The industrial specialists will teach for a nine hour period in one of the experienced teacher's regular classes. For legal purposes, of course, the regularly credentialed teacher will remain in the classroom but the instruction for this period will be in the hands of the industrial specialist. We have included in our project sufficient funds to supply an honorarium to both experienced teachers, for they will have to engage in a modest amount of additional work to implement this unit, and for the industrial specialists who will usually be obliged to leave their jobs for a short period of time.

Certain materials will be supplied in connection with this project which may be of value during the instructional period. For the auto mechanics classes, from 5 - 10 carburetors per class will be given to the teacher and industrial specialist. For the electronics classes, a series of 5 - 10 power supply units will be provided.

Anonymity of all participants will be carefully guarded, but general results of the entire research project will be distributed to any participant who requests a report. The considerable interest of vocational educators in this project (as attested to by an amazing number of requests for progress reports during the past two years) suggests that the results may have considerable national significance.

TEACHER OR SPECIALIST SIGN-UP SHEET

Check one: Auto Mechanics (Carburetion Unit)

Electronics (Power Supply Unit)

Today's Date ________

Teacher Name		Soc. Sec. #	School
Home Address			School Phone
City	Zip Code	'Home Phone	Free Periods

Date I plan to start unit

Class Period	Time		Room Number	Number of Students	Other Information
	From	To			

Specialist Name		
Address		Soc. Security #
City	Zip Code	Phone

Hours Available For Class Between 8 a.m. - 3 p.m.	From	To

Brief Technical Background:

Employer		
Address		
City	Zip Code	Phone & Ext.
Training Supervisor or Personnel Mgr.:		

Nature of Employer's Business:

Form 3

PATENT AGREEMENT

This agreement is made by me with The Regents of the University of California, a corporation, hereinafter called University, in part consideration of my employment, and of wages and/or salary to be paid to me during any period of my employment, by University, and/or my utilization of University research facilities.

I understand and agree that every possible patentable device, process, or product, hereinafter referred to an invention, which I conceive or develop while employed by University, or during the course of my utilization of any University research facilities, shall be examined by University to determine rights and equities therein in accordance with University's patent policy, and I further agree to furnish University with complete information with respect to each.

I further agree that, in the event any such invention shall be deemed by University to be patentable, and the University desires, pursuant to determination by University as to its right and equities therein, to seek patent protection thereon, I shall execute to University all rights, title and interest therein and to assist University in securing patent protection thereon.

I further agree that I will do all things necessary to enable University to perform its obligations to grantors of funds for research or contracting agencies as said obligations have been undertaken by University.

Anything herein contained to the contrary notwithstanding, University may relinquish to me all of a part of its right to any such invention, if in its judgment, it deems it desirable to so do.

By execution of this agreement I understand that I am not waiving any rights to a percentage of royalty payments received by University, as set forth in University Regulation No. 23, University Policy Regarding Patents.

I agree to be bound hereunder for and during any period of employment by University or for any period during which I conceive or develop any invention during the course of my utilization of any University research facilities.

Dated: ____________________________

____
Signature

PRE-TEST INSTRUCTIONS FOR
TEACHERS ADMINISTERING THEIR
OWN PRE-TESTS

IMPORTANT INSTRUCTIONS

Read Before Opening

1. This envelope contains test booklets and answer sheets. These materials represent a pre-test which should be administered before the instruction unit begins.
2. Please remind students to identify themselves and their instructor on the answer sheet.
3. It is essential that the instructor refrain from reading the test items at any time. Therefore, please do not attempt to answer student questions concerning any items on the test.
4. All test booklets and answer sheets should be returned to this envelope when the pre-test has been completed.

POST-TEST INSTRUCTIONS FOR
AUTO MECHANICS TEACHERS ADMINISTERING
THEIR OWN POST-TESTS

TEACHER INSTRUCTIONS

1. PLEASE DO NOT OPEN THIS PACKET UNTIL YOU ARE READY TO ADMINISTER THE POST-TESTS AT THE COMPLETION OF INSTRUCTION.

2. This packet contains Post-Tests, IBM Answer Sheets, Student Questionnaires, a Teacher Questionnaire, and a stamped-addressed envelope in which to return all of these materials.

3. Both Questionnaires and Post-Tests should be filled out on the same day at the completion of the unit.

4. Please instruct your class that they are not to mark the test booklet. All answers, except items 89-99, are to be made on the enclosed IBM Answer Sheet.
   a. Page 72 of the Post-Test serves as an answer sheet for items 89-99.
   b. When completed, please attach Page 72 to the IBM Answer Sheet.

5. The following information must be included on the IBM Answer Sheet.
   a. Student's name.
   b. Teacher's name. (Indicate if Teacher or Non-Teacher.)
   c. Unit name.
   d. High school.
   e. Date.
   f. Class period.

6. It is essential that the Post-Tests be completed before the students receive and fill out the Student Questionnaire.

7. Please allow all students sufficient time to complete both the Post-Test and the Student Questionnaire.

8. Kindly assemble all Post-Tests, Answer Sheets, and Questionnaires (both Student and Instructor) and return in the enclosed stamped-addressed envelope. Please include the Teaching Unit in this envelope also.

THANK YOU VERY MUCH FOR YOUR COOPERATION.

POST-TEST INSTRUCTIONS FOR
ELECTRONICS TEACHERS ADMINISTERING THEIR
OWN POST-TESTS

TEACHER INSTRUCTIONS

1. PLEASE DO NOT OPEN THIS PACKET UNTIL YOU ARE READY TO ADMINISTER THE POST-TESTS AT THE COMPLETION OF INSTRUCTION.

2. This packet contains Post-Tests, IBM Answer Sheets, Student Questionnaires, a Teacher Questionnaire, and a stamped-addressed envelope in which to return all of these materials.

3. Both Questionnaires and Post-Tests should be filled out on the same day at the completion of the unit.

4. Please instruct your class that they are not to mark the test booklet. All answers, except items 21 and 42-46, are to be made on the enclosed IBM Answer Sheet.
   a. The last page of the Post-Test serves as an answer sheet for items 21 and 42-46.
   b. When completed, please attach this last page to the IBM Answer Sheet.

5. The following information must be included on the IBM Answer Sheet.
   a. Student's name.
   b. Teacher's name. (Indicate if Teacher or Non-Teacher.)
   c. Unit name.
   d. High school.
   e. Date.
   f. Class period.

6. It is essential that the Post-Tests be completed before the students receive and fill out the Student Questionnaire.

7. Please allow all students sufficient time to complete both the Post-Test and the Student Questionnaire.

8. Kindly assemble all Post-Tests, Answer Sheets, Questionnaires (both Student and Instructor), and Teaching Unit and return in the enclosed stamped-addressed envelope.

THANK YOU VERY MUCH FOR YOUR COOPERATION.

APPENDIX K

ANSWER KEYS, PRE- AND POST-TESTS

APPENDIX K

Answer Keys: Pre- and Post-tests

Carburetion

*1. A
*2. A
3. C
4. E
5. A
6. D
7. D
8. E
9. E
10. B
11. B
*12. B
13. C
*14. D
15. A
16. B
*17. C
18. D
*19. C
*20. C
*21. B
22. A
23. A
24. A
25. A
26. B
27. B
28. B
*29. A
*30. A
*31. A
32. B
33. A
34. B
35. B
36. B
37. B
38. A
39. B
40. B
*41. B
42. A
43. A
44. B
*45. A
*46. A
47. B
48. A
*49. A
*50. B
*51. A
52. B
53. A
54. A
55. E
56. C
57. B
58. D
59. D
60. C
61. A
62. B
63. D
64. A
*65. C
66. A
67. B
68. C
69. B
70. B
*71. C
72. D
73. E
74. D
75. C
76. C
77. B
78. B
79. C
80. C
81. C
82. D
83. C
84. -----
*85. D
86. B
87. -----
88. A
89. O
90. G
91. H
92. I
93. Q
94. M
95. A
96. C
97. B
98. F
99. L
100. A

Power Supplies

1. B
*2. E
3. A
4. C
*5. B
*6. D
7. C
*8. A
9. C
10. B
11. B
12. D
*13. B, D
14. B
15. D
*16. C, E
*17. B
18. A
19. C
*20. B
21. diagram 5 pts.
*22. C
23. B
24. A
25. B
26. D
27. B, C
*28. A
*29. A
*30. A, C
31. B
32. A, C
33. D
34. D
35. D
*36. D
*37. C
*38. A
39. D
*40. D
41. B
*42. A
43. B
*44. A
*45. B
*46. C

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*Items selected at random for pre-test ("common" items).

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Performance Tests of Instructor Competence for Trade and Technical Education

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RETRIEVAL TERMS

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IDENTIFIERS

ABSTRACT

Two performance tests of teaching proficiency in the field of vocational education were developed during this project, one in the field of auto mechanics (carburetion) and one in the field of electronics (power supplies). An assessment was made of each test's ability to distinguish between experienced teachers and the non-teachers with respect to their ability to achieve prespecified instructional objectives. All subjects, teachers and non-teachers, were given sets of operationally defined objectives and attempted to achieve those goals during an instructional period of approximately 10 hours. Pre- and post-tests based explicitly on the objectives were given to each subject's pupils and average class achievement was used as the index of the teacher's proficiency.

In all, 28 auto mechanics teachers and 28 non-teachers instructed over 1200 pupils while 16 electronics and 16 non-teachers instructed over 700 pupils. Comparisons of pupil performance data revealed no systematic differences between the performance of the teacher and non-teacher group of either auto mechanics or electronics. These results were attributed to problems associated with the training of teachers as well as the reinforcement structures operating when they commence teaching.